instruNet®

Users Manual

January 5, 1998
Manual Version 1.25

This equipment complies with the requirements in Part 15 of FCC Rules for a Class A computing device.
Operation in residential areas may cause unacceptable RFI interference.

CE

Contents

Chapter 1 Installation

instruNet Family Overview 1-1
- Overview 1-1
- Controllers 1-1
- Network Devices 1-2
- instruNet Software 1-2

Computer Requirements 1-3
Constructing Your Network 1-3
- Install as many controllers as desired 1-3
- Install up to 16 Devices on each Network 1-3
- Each Controller includes Timer I/O Channels 1-4
- Each Controller includes one Terminator 1-4
- Each Network Device includes one cable 1-4
- You can purchase your own cables 1-4
- Minimum Base System 1-4
- Maximum Sample Rate 1-4
- Turn power OFF when cabling 1-5
- Large networks require external power supply 1-5

Hardware Installation 1-5
Software Installation 1-7
- Windows/x86 Computer 1-7
- Macintosh Computer 1-7

Verifying That Your Systems Is Working Properly 1-8
instruNet BASIC Software License Installation 1-10

Chapter 2 *instruNet* Tutorial

Record Waveforms in 7 Easy Steps 2-1
Digitizing Analog Signals into the Computer 2-4
The instruNet Data Tree 2-8
Explore Your World 2-10
- The Network Page 2-10
- The Probe Dialog 2-11
- Channel Address 2-12

Working with Sensors 2-14
Working with instruNet BASIC 2-18
Working with Calibration, Different Scales, and Mapping 2-21
Working with Digital Filters 2-22
Working with Voltage Output Channels 2-25
Working with Digital I/O Channels 2-26
Working with Controller Digital Timer I/O Channels 2-27
Working with The Controller Time Since Reset Channel 2-30
Working with Multiple Controllers 2-31
Next Step 2-31

Chapter 3 Connecting to Sensors

Connecting a Sensor to instruNet 3-2
Sensor Reference 3-6
- Single-ended Voltage Measurement 3-6
- Differential Voltage Measurement 3-7
- Bridge Ratio Voltage Measurement 3-7
- Current Measurement 3-8
- Resistance Measurement: Voltage Divider Circuit 3-8
- Resistance Measurement: Bridge Circuit 3-9
- Strain Gage Measurement: Voltage Divider Circuit 3-10
- Strain Gage Measurement - Quarter Bridge 3-11
- Strain Gage Measurement - Half Bridge (Bending) 3-12
- Strain Gage Measurement - Half Bridge (Axial) 3-13
- Strain Gage Measurement - Full Bridge (Bending) 3-13
- Strain Gage Measurement - Full Bridge (Axial I) 3-14
- Strain Gage Measurement - Full Bridge (Axial II) 3-15
- Temperature Measurement (RTD) Voltage Divider 3-15
- Temperature Measurement (RTD) Bridge Circuit 3-17
- Temperature Measurement Thermocouple 3-18
- Temperature Measurement Thermistor 3-19
- Sensor Reference Footnotes 3-20

Chapter 4 A Tutorial For Programmers

Programming Overview 4-1
- instruNet Function Call 4-1
- Simple Format Functions 4-2
- Digitizing 4-3
- Support Functions 4-4
- Interface Files 4-5
- Programming Examples 4-5
- instruNet Data Types 4-5
- instruNet Macros 4-6
- Example Code 4-6
- Tutorial Summary 4-7
- Getting Started 4-8

Working with any C compiler 4-8
Getting Started with Macintosh Symantec C/C++ 4-9
Getting Started with Macintosh metrowerks CodeWarrior C/C++ 4-10
Getting Started with Microsoft Visual Basic for Windows 95/NT 4-12
Getting Started with Microsoft C/C++ for Windows 95/NT 4-12

Chapter 5 instruNet World Program Reference

The Network Page 5-2
Overview 5-2
Surfing The Net 5-3
Modifying Fields 5-3
Channels 5-3
Turning A Channel On 5-4
Pull Down Menus 5-4
Saving Your Configuration 5-4
Reconnecting With A Changed Network 5-4
Buttons 5-4
The Record Page 5-5
Setting Up Channels 5-5
Setting Up Displays 5-6
Oscilloscope or Strip Chart 5-6
Setup Options 5-8
Saving Data 5-10
Trigger Options 5-11
Getting Ready to Digitize 5-12
Digitizing 5-12
If Your Sample Rate is Too Fast 5-12
Buttons 5-12
The Test Page 5-14
Buttons 5-15
The BASIC Page 5-16
Buttons 5-16

Chapter 6 Hardware Reference

Model 200 PCI and 220 Nubus instruNet Controllers 6-2
Specifications 6-2
Model 230 PC-Card instruNet Controllers 6-4
Specifications 6-4
Model 100, 100B, and 100HC Network Device 6-5
Specifications 6-5
Model 300 Power Adaptor 6-9
Model 311 and 322 Power Supplies 6-10
Model 330 Electrical Isolator 6-11

Chapter 7 Channel Reference

Channel Reference 7-1

Chapter 8 Settings Reference

Settings Reference 8-1

Chapter 9 *instruNet* BASIC

Overview 9-1
- Software License 9-1
- BASIC Page 9-1
- Buttons 9-1
- Benefits 9-2

Print Digitized Channels Example 9-2
Feedback Control Example 9-4
Channel Setup and Calibration Example 9-5
File I/O Example 9-6
Programming Example 9-7
Mathematical Expressions 9-8
- Logical Operators 9-9
- Conditionals 9-9
- Basic Functions 9-9
- Round Off Functions 9-9
- Statistical Functions 9-9
- String Functions 9-9
- instruNet Hardware 9-9
- Trig. Functions 9-10
- Temperature Conversion Functions 9-10
- Numerical Constants 9-10
- Base Keywords 9-10
- Time Keywords 9-10

Debugging 9-11
Objects 9-11
- Program Code 9-11
- Commands 9-11
- Pages & Buttons 9-11
- Variables! 9-11
- Strings$ 9-12
- Defines# 9-12
- Object Database 9-12
- Comments 9-12
- Channel Address 9-12
- Channel Lists 9-12
- Text Files 9-12
- BASIC Files 9-12
- Startup.iBs 9-12
- Version 1.25 9-13

Code Syntax 9-13
- Command Line 9-13
- [item1/item2/...] 9-13
- *Italics* 9-13
- (parameter) 9-13
- "Text" 9-13
- Math Expressions 9-13
- \r and \t 9-13
- Floating Point 9-14
- Object Names 9-14

Object Management Commands 9-14
- Append 9-14
- Clear 9-14

Copy 9-14
Define 9-14
Delete 9-14
String$ = string items 9-15
Variable! = math expression 9-15
Programming Commands 9-15
Debug 9-15
End 9-15
For ... Next 9-15
Goto ... Label 9-15
If, elseif, else, EndIf 9-16
If (...) then ... 9-16
License 9-16
Loop 9-16
Synchronize 9-16
While (...) ... EndWhile 9-16
User Interface Commands 9-17
Alert 9-17
Beep 9-17
Delay 9-17
Erase 9-17
Print 9-17
Question 9-18
Page & Button Commands 9-18
NewPage 9-18
NewButton 9-18
Press 9-18
Select 9-18
Show/Hide page 9-18
Show/Hide button 9-19
Calibrate Hardware 9-19
Calibrate Gages 9-19
Calibrate Bridges 9-19
Calibrate VDividers 9-19
Calibrate Vinit 9-19
Calibrate Int1/Int2 9-19
Digitize 9-19
SetChannel 9-20
SetChannelBit 9-20
SetField 9-20
SetTrigger 9-20
Table 9-20
File Commands 9-21
Close 9-21
Create 9-21
Flush 9-21
Open 9-21
SetMasterDir 9-21
SetPointer 9-21
SetSize 9-21

Appendix I Troubleshooting

Identifying Symptoms and Possible Causes A-I-1
If the instruNet PCI Controller Board is not seen by the instruNet World Software A-I-3
instruNet Technical Support Form A-I-5

Appendix II Error Codes

Error Codes A-II-1

Appendix III Working With Spreadsheets

Overview A-III-1

Appendix IV Working With Application Software

Working with DASY*Lab* A-IV-1
Working with LabVIEW A-IV-1
Working with HP VEE A-IV-2
Working with MicroLab A-IV-2
Working with Origin A-IV-2
Working with TestPoint A-IV-2

Appendix V Working With instruNet Files

instruNet File Types A-V-1
Reading instruNet Files From C A-V-1

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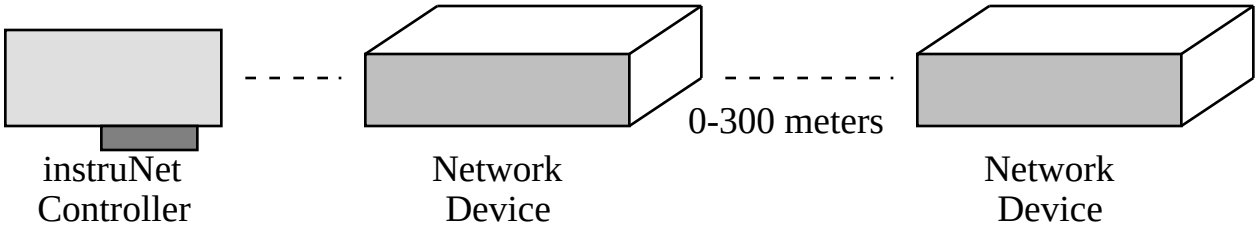
1 Installation

This chapter explains how to install instruNet hardware and software onto your computer, and how to verify that your instruNet System is operating properly. With new systems it is recommend that you first do the Chapter 1 Installation, and then proceed to the Chapter 2 Tutorial.

instruNet Family Overview



Overview

instruNet is a hardware and software product family that enables one to interface computers such as the Apple Macintosh and Windows 95/NT x86 PC Compatible computers to common laboratory and factory equipment for purposes of data acquisition and control. instruNet utilizes a high speed network approach that is both low cost and flexible for providing voltage inputs, voltage outputs, digital inputs, digital outputs, and timer I/O to the computer.

Controllers

Each instruNet Network is controlled by a Network Controller board that installs into a computer. A different controller board is used with each common bus interface (e.g. Nubus, PCI, PC-Card), yet they are all very similar internally. Each Controller is an independent computer in itself that utilizes a powerful 32-bit microprocessor and onboard RAM to control all aspects of data acquisition along its network. One can install as many Controllers as desired, space permitting, since each controller operates independently. Each network supports up to 32 Network Devices. Each Device is a small box (e.g. 10cm x 12cm x 25cm) that is connected in a daisy-chain configuration to form a chain of Devices. Each network can be up to 300 meters long. All networks are anchored with an instruNet Terminator at the far end, and an instruNet Controller at the near end. This makes instruNet a cost effective method for designing large scale, high speed, multi-channel data acquisition systems. The following table lists the instruNet Controllers described in this manual.

Model	Controller	Bus	Size	Computer Required
200(s)	PCI Controller	PCI	7" x 4"	Windows 95/NT x86 Compatible Computer with PCI Rev ≥2.0 compliant, 32-bit, +5V slot; or Macintosh with PCI Slot.
230(s)	PC-Card Controller	PC-Card	2" x 3"	Windows 95 x86 Compatible Computer with Type II PCMCIA compliant ≥ v2.1 (or ≥ PC-Card 95) PC-Card slot.
220(s)	Nubus Controller	Nubus	7" x 4"	Macintosh with ≥ 7" Nubus Slot

Table 1.1 instruNet Controllers described in this Manual

Network Devices

Network Devices typically provide voltage input channels, voltage output channels, digital inputs and digital outputs. The following Network Devices are described in this manual:

	Voltage Inputs			Voltage Outputs			
Model	# of Channels	Range	Absolute Accuracy	# of Channels	Write Accuracy	Read-back Accuracy	Digital I/O
100	16ch w/ screw terminal access	+/- 5V +/-.6V +/-80mV +/-8mV	+/-2000µV +/-400µV +/-75µV +/-40µV	8ch with 4mA/1KpF Drive Capability	+/- 40 mV	+/- 3mV	8 Bidirectional I/O Bits
100B	Same as #iNet-100, yet with 16 additional BNC connectors for 16se voltage inputs.						
100HC	Same as #iNet-100, yet with voltage outputs that have 15mA/.01uF drive capability.						

Table 1.2 instruNet Network Devices described in this Manual

instruNet Software

instruNet includes software to interrogate, test, configure, and do I/O with all network channels. This includes an application program called "instruNet World"; drivers; interfaces to C, and Visual BASIC. instruNet World and the instruNet Driver can configure all I/O channels, store your settings, view digitized data in real time, stream data to disk, and scroll through your waveform post-acquisition. instruNet software runs on both a PC and a Macintosh.

Free Updates

Free software and manual updates are available on the web at:

www.instrunet.com

Computer Requirements

The following table summarizes the computer required to run instruNet:

Model	Controller	Computer Required	OS Required	RAM Required	HD Required	Slot Required
200(s)	PCI Controller	IBM PC or Compatible ≥ 80486	Windows 95/NT	≥ 4MB	≥ 6MB free	PCI Slot, ≥6.8", Rev ≥2.0 compliant, 32-bit, +5V
200(s)	PCI Controller	68K w. math coprocessor or Power Macintosh	System ≥7.0	≥ 4MB	≥ 6MB free	PCI Slot, ≥6.8"
230(s)	PC-Card Controller	IBM PC or Compatible ≥ 80486	Windows 95	≥ 4MB	≥ 6MB free	Type II PC-Card Slot with ≥ v2.1 PCMCIA compliant card services
220(s)	Nubus Controller	68K or Power Macintosh	System ≥7.0	≥ 5MB	≥ 6MB free	Nubus Slot, ≥6.8"

Table 1.3 Computer Requirements for instruNet Controllers

Constructing Your Network

instruNet hardware is 100% plug and play for all computers. instruNet does not use dip switches, DMA, low memory, interrupts, and I/O addresses. All you need to do is plug the Controller board into your computer, connect your network devices, slap a terminator onto the end of your network and run the instruNet World software. The instruNet driver automatically determines the physical locations of all installed Controllers and Network Devices.

Please keep in mind the following when designing and constructing your network:

1. **Install as many controllers as desired**
   The number of available slots determines the number of controllers (i.e. networks) that can be installed, and simultaneously run, on one computer. The software numbers each controller in the order that they are found in the computer ("netNum" ranges from 1 to # of Controllers). Each controller manages its own network of devices. In most cases, only one controller is necessary. The advantage of multiple controllers is that each is its own real-time machine, and more controllers can do more things simultaneously.

2. **Install up to 16 Devices on each Network**
   One can attach, in daisy-chain configuration, up to 16 Network Devices to each instruNet Controller. Each Network Device has two DB-25 connectors, one for network input (male), and another for network output (female). To connect a chain of Network Devices, one must connect each input connector to each output connector via a DB-25 Male/Female cable. The Controller is attached to the first device in the chain, and an instruNet Terminator is attached to the far end of the

chain. Due to the male/female polarization, the network cannot be installed incorrectly with instruNet Male-Female cables.

3. Each Controller includes Timer I/O Channels
Each Controller (except iNet-230 PC-Card) provides 10 Timer I/O channels. Each channel can be programmed as a digital input, digital output (0V/4V TTL compatible), clock output, or period measurement input.

4. Each Controller includes one Terminator
One instruNet Terminator must be installed at the end of each network chain. This terminator mates with the output connector of the last device. instruNet Controllers include an instruNet Terminator, therefore they do not need to be purchased separately. *Caution:* Do not use a SCSI Terminator in place of an instruNet Terminator -- they are different.

5. Each Network Device includes one cable
Each instruNet Network Device is shipped with one 10foot DB-25 Cable Male/Female cable for purposes of configuring your network.

6. You can purchasing your own cables
If you want a specific cable length, you can purchase your own DB-25 male to DB-25 female, shielded, wired point-to-point (i.e. pin X to pin X) cables. We recommend 24 gauge wire for > 4 meters; however 28 gauge is fine with ≤4m. Twisted pairs are recommend for >4 meters with the following wires twisted: 1 & 14, 2 & 15, 3 & 16, 4 & 17, 5 & 18, 6 & 19, 7 & 20, 8 & 21, 9 & 22, 10 & 23, 11 & 24, 12 & 25 (these are physically next to each other in the connector).

A supplier of high quality DB25M/DB25F instruNet compatible cables is:

Global Computer Supplies
11 Harbor Park Dr. Dept RC
Port Washington, NY 11050

Tel 800-845-6225 or 516-625-6200
Fax 516-625-6683
www.globalcomputer.com

Global Part #	Description	Length	Low Cap	# of Shields
#RCC91445A	DB25m-DB25f	6ft	no	double
#RCC91445B	DB25m-DB25f	10ft	no	double
#RCC91445C	DB25m-DB25f	15ft	no	double
#RCC91445D	DB25m-DB25f	25ft	no	double
#RCC91445E	DB25m-DB25f	50ft	no	double
#RCC4067A	DB25m-DB25f	100ft	yes	single
#RCC4067B	DB25m-DB25f	150ft	yes	single
#RCC4067C	DB25m-DB25f	250ft	yes	single
#RCC4067X-ft	DB25m-DB25f	any	yes	single

A supplier of high quality twisted pair, low capacitance, double-shielded cable without connectors is Belden, Inc. The following is an outstanding cable choice: Belden Cable Part #8112; Low Capacitance, RS-485/RS-232 cable; available in 100ft, 500ft, and 1000ft lengths; 12.5 Pairs, with copper braided shield; 24 gage wire; 41pF/meter between pairs; 72pF/meter between a wire and the shield; 78ohms/killometer wire resistance.

7. **Minimum Base System**
   One Controller and one Network Device is all you need to purchase to digitize waveforms, save them to disk, and view them.

8. **Maximum Sample Rate**
   As the physical length of the network increases, the maximum aggregate data acquisition sample rate decreases from 166Ks/sec maximum with a short network (e.g. 5 meters) to 4.15Ks/second aggregate with a long network (e.g. 300 meters).

   This maximum aggregate rate includes both input and output channels. For example one instruNet network could support two voltage input channels and two voltage output channels at a maximum rate of 41.5Ksamples/sec for each channel (i.e. 166Ks/sec throughput). The same network would allow 4 channels of voltage input to be acquired at 41.5Ks/sec per channel. The maximum aggregate rate can be increased by installing additional instruNet networks and controllers. For example, two controllers could support 332Ks/sec aggregate throughput if run simultaneously.

   When the instruNet powers up, it empirically tests (i.e. it test the cable impedance) of the network to determine its maximum throughput rate (i.e. 4.15K/sec to 166Ks/sec). The maximum rate is decreased by: additional network devices, longer aggregate network cable length, non-twisted pair cables, and thinner cable wire (e.g. 28 gauge instead of 24 gauge).

9. **Turn power OFF when cabling**
   Always turn the computer and powered Network Devices Off before adjusting network cables.

10. **Large networks require external power supplies**
    The instruNet network cable provides power from the computer to the external Network Devices. As the number of devices increases (more current drawn), and the cable lengths increases (more voltage drops), it becomes increasingly necessary to add an external power supply for the Network Devices. We recommend adding an external power supply if your cable is > 50 meters, or for every 4 Network Devices after your 3rd Device. In other words, only add an external power supply if you have more than 3 network devices, or if your network is longer than 50 meters.

Hardware Installation

To install an instruNet network, please:

1. Read the previous "Constructing your Network" discussion.
2. Turn OFF your computer.
3. Turn OFF all powered devices connected to your network.
4. Touch bare metal on your computer to discharge personal static electricity.
5. Remove the cover from your computer to gain access to the card slots, as needed.
6. Remove the small I/O fence cover from the back of your computer, as needed.

7. If you require access to an available Controller Digital/Timer I/O Channel, run a 34-wire ribbon cable from the Controller's 34pin header connector, out of the computer, any way you can (e.g. through another slot opening), to the breakout of your choice (e.g. a screw terminal block), as illustrated below:

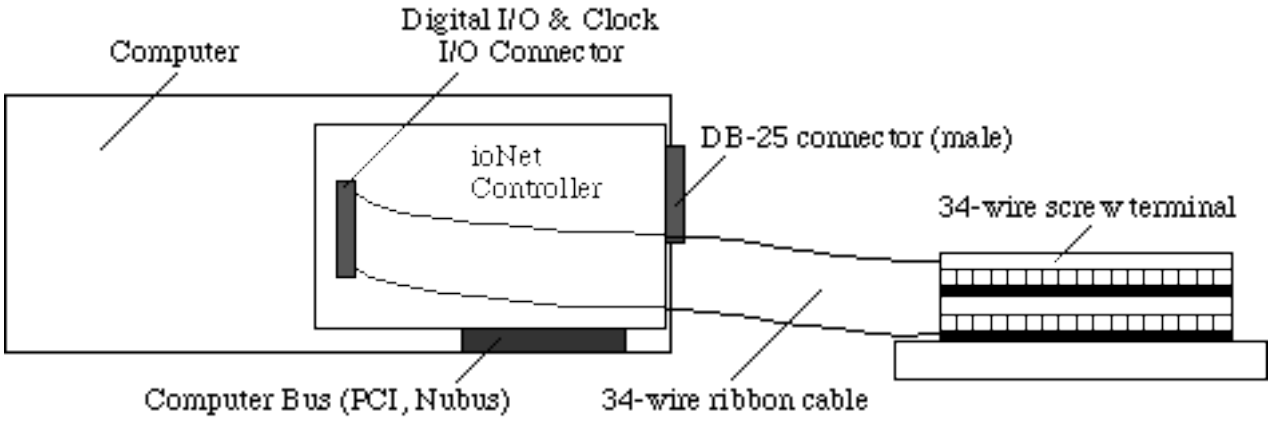


Figure 1.4, Installing an instruNet Controller into a Computer

8. Install the instruNet controller(s) into the computer's expansion slot(s). If working with a PCI Card, make sure the Controller connector is well seated and inspect this connection with a strong light to make sure the printed circuit board fingers are aligned with their mating connector pins.
9. Bolt the board metal I/O fence to the computer, as needed (some computers do this). Please skip this step if tightening this bolt causes the card to not seat well in its connector.
10. Put the cover back onto the computer, as needed.
11. Attach the external instruNet Network Devices in a daisy chain configuration, as illustrated below.

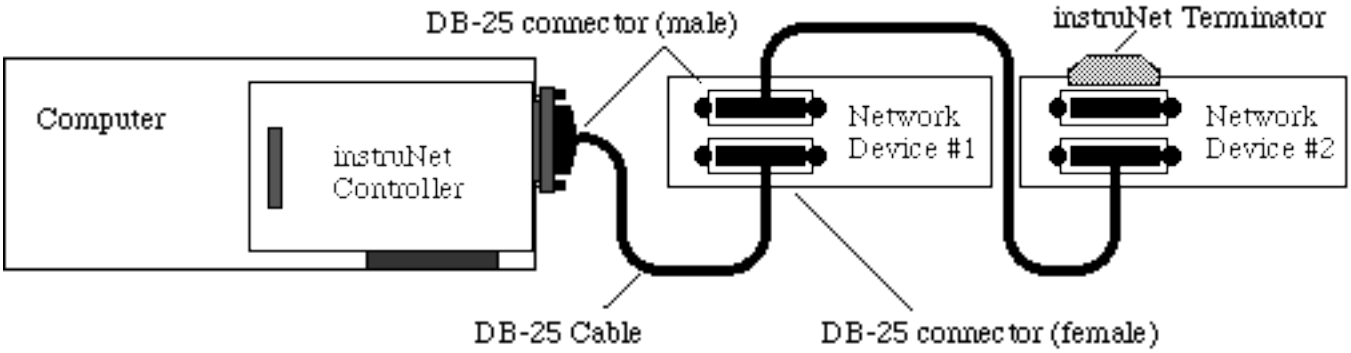


Figure 1.5, instruNet Network

12. Tighten all DB-25 thumbscrews until lightly snug.
13. Install an instruNet Terminator on the end of each network.
14. It is recommended that the user attach the instruNet instrumentation ground (i.e. instruNet box and instruNet GND screw terminals) directly to Earth ground with a 16gauge wire from the left-most GND screw on the instruNet box, to the closest Earth ground (e.g. screw next to power socket). This will reduce the chance of RFI coupling into the instruNet ground, and is required if the user wants to meet EC and FCC RFI guidelines.

15. If working with an iNet-230 PC-Card, attach an external power supply (e.g. iNet-311 or 322) to the PC-Card 5pin DIN connector. This supplies power to the external network devices (i.e. not the PC-Card itself).
16. Turn the computer power ON and then Turn ON all powered devices attached to the instruNet network.

Software Installation

Windows 95 Computer

1. Make sure you are on a Windows 95 computer (≥ 80486) with at least 4MB of ram (8MB is better).
2. If reinstalling new software over Version ≤1.22 software: Run The "System" Control Panel, select "Device Manager", select "View Devices by connection", expand "PCI bus", if you see "? PCI Card" select it & press the Remove button, and exit "System" Control Panel. Do not install a PCI card driver at this time.
3. Run the "SetupEx.exe" Windows installer program. This creates an instruNet directory, installs many files into it, creates an instruNet program group, installs "Windows\System\Inet32.dll", installs "Windows\ System\Inet95.vxd", and installs "WindowsNT\System32\drivers\inet.sys".
4. Turn the computer off, install the instruNet pci card, attach the instruNet network devices, attach the instruNet terminator, tighten the thumbscrews, and then power the computer back on.
5. It may ask you for a PCI Card Driver on boot-up. Navigate via the Browse button to "Program Files \ instruNet \ Win95 iNet PCI Driver \ inet95.inf".
6. Run the "Start > Programs > instruNet > instruNet World" application in the "instruNet" folder to operate and test your instruNet hardware and software.
7. If you hit a problem, please proceed to Appendix I.

Windows NT Computer

1. Make sure you are on a Windows NT computer (≥ 80486) with at least 4MB of ram (8MB is better).
2. Turn the computer off, install the instruNet pci card, attach the instruNet network devices, attach the instruNet terminator, tighten the thumbscrews, power the computer back on, and log in as the "Administrator".
3. Run the "SetupEx.exe" Windows installer program. This creates an instruNet directory, installs many files into it, creates an instruNet program group, installs "Windows\System\Inet32.dll", installs "Windows\ System\Inet95.vxd", and installs "WindowsNT\System32\drivers\inet.sys".
4. Reboot the computer and log in under any account.
5. Run the "Start > Programs > instruNet > instruNet World" application in the "instruNet" folder to operate and test your instruNet hardware and software.
6. If you hit a problem, please proceed to Appendix I.

Macintosh Computer

1. Insert the instruNet Macintosh disk into your computer.
2. If the items on the disk are compressed (i.e. the file has a ".sea" or ".sit" suffix), uncompress it by double-clicking on it's ".sea" file and telling the computer to place the decompressed folder on your hard disk.
3. Copy a driver file from the "instruNet" folder on your hard disk into the Extension folder, within the System folder. Several driver files are provided. Please refer to the table below for the Driver that is most appropriate for your computer. For example, on a Power Macintosh 7200 computer, one would place a copy of the "`instruNet Driver (ppc)`" file into the Extensions folder.

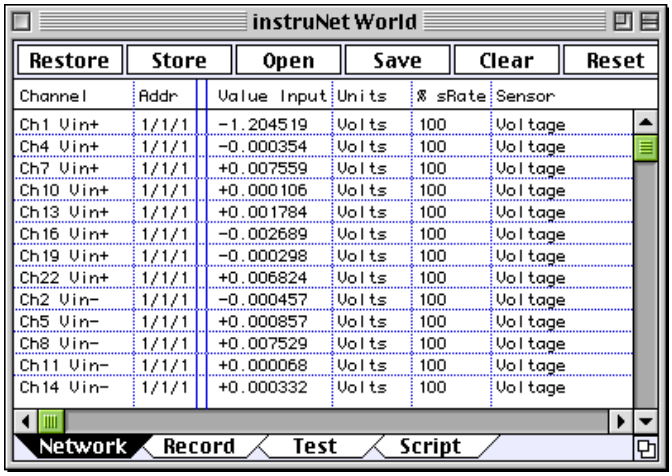
Computer	Appropriate Driver File
Power Macintosh	`instruNet Driver (ppc)`
68K Macintosh w Floating Point Co-Processor	`instruNet Driver (68K & FPU)`

Table 1.4, Macintosh Driver files

Verifying That Your System Is Working Properly

Verify that your hardware and software is working in 5 easy steps:

1. Run the "`instruNet World`" application program ("`instruNet World Mac`" on Macintosh, and "`instruNet World Win32.exe`" on a Microsoft Windows computer), in the instruNet directory. A window will open, similar to what is pictured to the right. If necessary, you might need to click on the Network tab at the bottom of the window to select the Network page. If this window opens, then you know your instruNet driver file is installed and working correctly. The list of channels shown in the window's table will vary, depending on what instruNet hardware is connected. If the instruNet window does not appear, then check the Software Installation section at the beginning of this chapter to make sure that the software has been installed correctly. If it appears that the software is installed correctly but not functioning properly then see *Appendix I Trouble Shooting*.


instruNet World
Restore
Store
Open
Save
Clear
Reset
Channel | Addr | Value Input | Units | % sRate | Sensor
Ch1 Vin+ | 1/1/1 | -1.204519 | Volts | 100 | Voltage
Ch4 Vin+ | 1/1/1 | -0.000354 | Volts | 100 | Voltage
Ch7 Vin+ | 1/1/1 | +0.007559 | Volts | 100 | Voltage
Ch10 Vin+ | 1/1/1 | +0.000106 | Volts | 100 | Voltage
Ch13 Vin+ | 1/1/1 | +0.001784 | Volts | 100 | Voltage
Ch16 Vin+ | 1/1/1 | -0.002689 | Volts | 100 | Voltage
Ch19 Vin+ | 1/1/1 | -0.000298 | Volts | 100 | Voltage
Ch22 Vin+ | 1/1/1 | +0.006824 | Volts | 100 | Voltage
Ch2 Vin- | 1/1/1 | -0.000457 | Volts | 100 | Voltage
Ch5 Vin- | 1/1/1 | +0.000857 | Volts | 100 | Voltage
Ch8 Vin- | 1/1/1 | +0.007529 | Volts | 100 | Voltage
Ch11 Vin- | 1/1/1 | +0.000068 | Volts | 100 | Voltage
Ch14 Vin- | 1/1/1 | +0.000332 | Volts | 100 | Voltage
Network
Record
Test
Script

2. Press the **Test** tab at the bottom of the window to select the Test page, and then press the **Search** button at the top of the window. A report will print that lists the controllers and network devices that are currently installed on your computer. For example, the report below shows one Controller, and one Model 100 Network Device.

```
instruNet HARDWARE SEARCH RESULTS:
Date & Time: 10/2/1997, 12:12:41
Net Dev Mod  Device
----------------------------------------
 0   0   0  Mac OS Ver 7.5.3
 0   0   1    instruNet Driver Version 1.24
 0   0   1    instruNet BASIC license 31-048353-62581
 1   0   1       Nubus Controller #iNet-220 (slot #13, 4000KBD, 6us, 94%)
 1   1   1          Device #iNet-100 (SN37532, Cal 9/28/1997, Rev 4, 30.99C, 6us, 17mA)
```

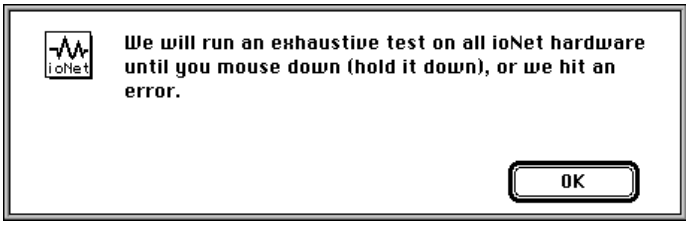
If this does not match what you believe is installed on your network, then check your hardware installation (cables, power, etc). Also, it is possible that the

instruNet Driver is older than the devices on your network, which means you need the latest driver that recognizes these new devices. The instruNet Driver is always listed as the 1st installed item.

3. Press the **Test** button at the top of the window to test your controllers and devices, and to report any problems if found. The duration of the test can vary from 1 to 120 seconds depending on the size of the networks, and the speed of the computer. If no problems are found, a report similar to the one below is printed in the window:

```
INSTRUNET QUICK TEST RESULTS:
Date & Time: 10/12/1995, 12:53:23
We ran 0.510029 million tests and did NOT hit 1 error.
```

4. Press the **Big Test** button to run an exhaustive test. An alert similar to the one on the right will appear to communicate that the computer will test all instruNet hardware until there is an error, or until you press the mouse button down. It will test your network(s) all night long if you let it. Press OK to begin the Big Test. Wait 20 seconds or longer. If an error occurs while testing, an alert will appear and the error message will also be printed in the window. Refer to *Appendix II instruNet Error Codes* for more information on error codes, and *Appendix I Trouble Shooting* for tips on de-bugging if necessary. If no error alerts appear, and you want to stop the test, press the mouse button down and hold it down until the an alert appears announcing the end of the test. Click OK to exit this alert. The test results are printed in the window, in a format similar to what is shown below:




```
INSTRUNET BIG TEST RESULTS:
Date & Time: 11/7/1995, 15:53:19
We will run an exhaustive test on all instruNet hardware until
   you mouse down (hold it down), or we hit an error.
We ran 2.170272 million tests and did NOT hit 1 error.
```

Big Test is identical to **Test**, except it runs for a longer period of time and is useful at finding intermittent problems that only occur once every minute, hour, or day. Big Test can be run overnight for extensive testing of all hardware.

5. You are done! Your instruNet hardware and software is installed correctly and running beautifully. Please proceed to Chapter 2, Tutorial to learn more.

instruNet BASIC Software License Installation

The instruNet "s" series controllers (i.e. iNet-200s, 220s and 230s), and the instruNet BASIC License, #iNet-350, all include a license to the instruNet BASIC Software. To register this liscense and enable this feature, one must:

1. Install the standard instruNet software, as describe in the previous pages of this chapter.

2. Run the "`instruNet World`" application program (e.g. in the instruNet directory) and then press the BASIC tab at the bottom of the window.

3. Locate your instruNet BASIC License number included with the #iNet-200s, #iNet-220s, #iNet-230s, and #iNet-350. This is printed on a sheet of paper entitled "instruNet BASIC Software License" and is in a "zz-ssssss-yyyyy" format.

4. Type the following into the BASIC window:

   ```
   License zz-ssssss-yyyyy
   ```

   substituting the number printed on your license document for the zz-ssssss-yyyyy. For example, if your license was 23-012345-54321, you would type:

   ```
   License 23-012345-54321
   ```

   into the window. Please do not place a space before or after the "-".

   The license is in a zz-ssssss-yyyyy format, where ssssss matches the serial number of your controller card. The license for each controller card is unique. If you purchased instruNet BASIC #iNet-350, you will need to contact your supplier to make sure you get a license number that matches your controller card.

5. Press the Execute button. An alert should appear notifying that the license was accepted and was stored in the Operating System directory, in a file called "iNetLcns.txt", within your computer. You will not need to do this operation again on this computer, provided the current OS directory stays in service. To view the instruNet BASIC license number installed on a computer, press the Test tab at the base of the window and then press the Search button to print out the license number.

   You have now enabled the powerful instruNet BASIC feature. If this feature was not enabled, BASIC code would still execute, yet in demo mode where data read from instruNet hardware is simulated.

6. After learning about instruNet via Chapter 2 Tutorial, we recommend venturing on to Chapter 9, instruNet BASIC, to learn more about this powerful feature.

2 *instruNet* Tutorial

This chapter is a step-by-step tutorial that shows the user how to navigate within the world of instruNet. Controlling instruNet hardware can be done manually though the instruNet World application program, or through the programming languages Visual Basic and C. This chapter deals exclusively with the easy-to-use application program instruNet World application program while Chapter 4 covers programming languages. The instruNet World allows you to set up and probe your network, record waveforms, save them to disk, load them from disk, and view them post acquisition.

Record Waveforms in 7 Easy Steps

This section explains how to record waveforms in several easy steps.

1. **Install your hardware and software per instructions in Chapter 1**
   If your instruNet World hardware and software is not installed, please install it now, as described in *Chapter 1*.

2. **Run the instruNet World application program.**
   Locate the instruNet world application program within the instruNet folder on your hard disk and then:

   Win 95/NT: Double-click on "`instruNet World Win32.exe`", or run "Start > Programs > instruNet > instruNet World".
   Macintosh: Double-click on the "`instruNet World Mac`" icon.

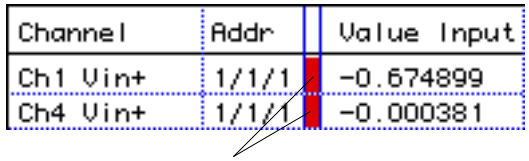
3. **Select the Network Page.**
   instruNet World offers several Pages: Record, Network, and Test. Click on the Network tab at the bottom of the window to select the Network page. The Network tab will inverse black to indicate the Network page is selected.

Click here to select the Network Page

4. Enable a Channel for digitizing.

A channel is enabled for digitizing by clicking on the small cell between the addr and Value Input columns within the Network page, as illustrated below. Once enabled, the channel will be digitized when the user presses the Start button on the Record page. To disable a channel, one must click the digitize on/off cell again. This digitize on/off cell is black or red when On, and white when Off. Any number of channels can be selected for digitizing.

Please enable two voltage input channels (e.g. "Ch1 Vin+" and "Ch4 Vin+" on the Model 100) for digitizing, as illustrated below. Voltage input channels are typically labeled ChX Vin+ or ChX Vin-. These work identically when doing single-ended voltage measurement (i.e. read a voltage between an input terminal and ground), and are used as a pair when doing differential voltage measurement (i.e. reading a voltage between 2 input channels). If instruNet voltage input hardware is not installed, you will not be able to digitize. Also, note that the contents of the Network page may vary depending on what is installed on your computer.



To Enable/Disable a Channel for digitizing

5. Attach a signal source.

If possible, attach a signal source to at least one channel's hardware input terminal. For example, one might attach a Function Generator output to the instruNet "Ch1 Vin+" input terminal, and the Function Generator's ground to the instruNet "AGND" terminal. It is not necessary to connect a signal source to do the tutorial, however, the displayed waveforms are more interesting if a signal is applied; otherwise, you get a flat line at 0Volts.

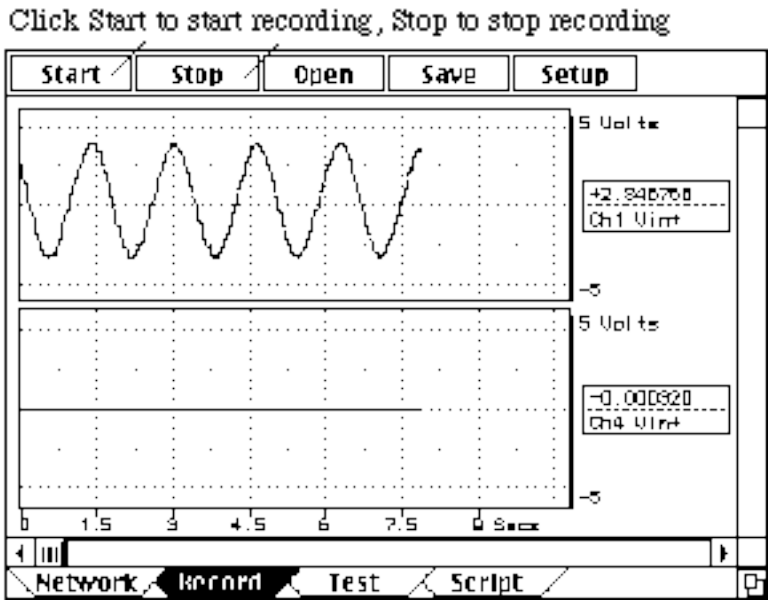
6. Select the Record Page.

Select the Record page by clicking on the Record tab at the base of the window, as illustrated below.

Click here to select Record Page

7. Tell instruNet to start digitizing.

Click the Start button at the top of the window to tell instruNet to record and display channels that have been enabled for digitizing (e.g. "Ch1 Vin+"). You should see your waveforms move across the screen as they are digitized in real-time, as illustrated below.



8. Tell instruNet to stop digitizing
Click the Stop button to stop the digitizing process.

9. Save your waveforms to disk
Click the Save button to save your waveforms to disk. When the save dialog appears, type a name and choose a convenient location to save the data. Saving does not specify a file name, but rather a folder name in which all acquired waveforms and a preferences file are saved. For example, if you digitized 2 waves and then clicked Save, 3 files would be stored in your: one named "instruNet.prf" that contains the Field settings, and two files that have the same name as the two channels, that contain the wave data.

10. Record again
Click the Start button to start recording again, and then click the Stop button after a few moments.

11. Load your saved waves from disk
Click the Open button to load in the previously saved waves from disk. A File open dialog will appear, and it is here that you must select one of your previously saved files (e.g. "instruNet.prf", "Ch1 Vin+" or "Ch4 Vin+"). After your waves are loaded in, they should appear in their displays .

Digitizing Analog Signals into the Computer

The Setup button at the top of the Record page opens a dialog box that effects the manner in which waves are recorded.

- Click the Setup button to open the Setup dialog, as illustrated in Figure 2.1.

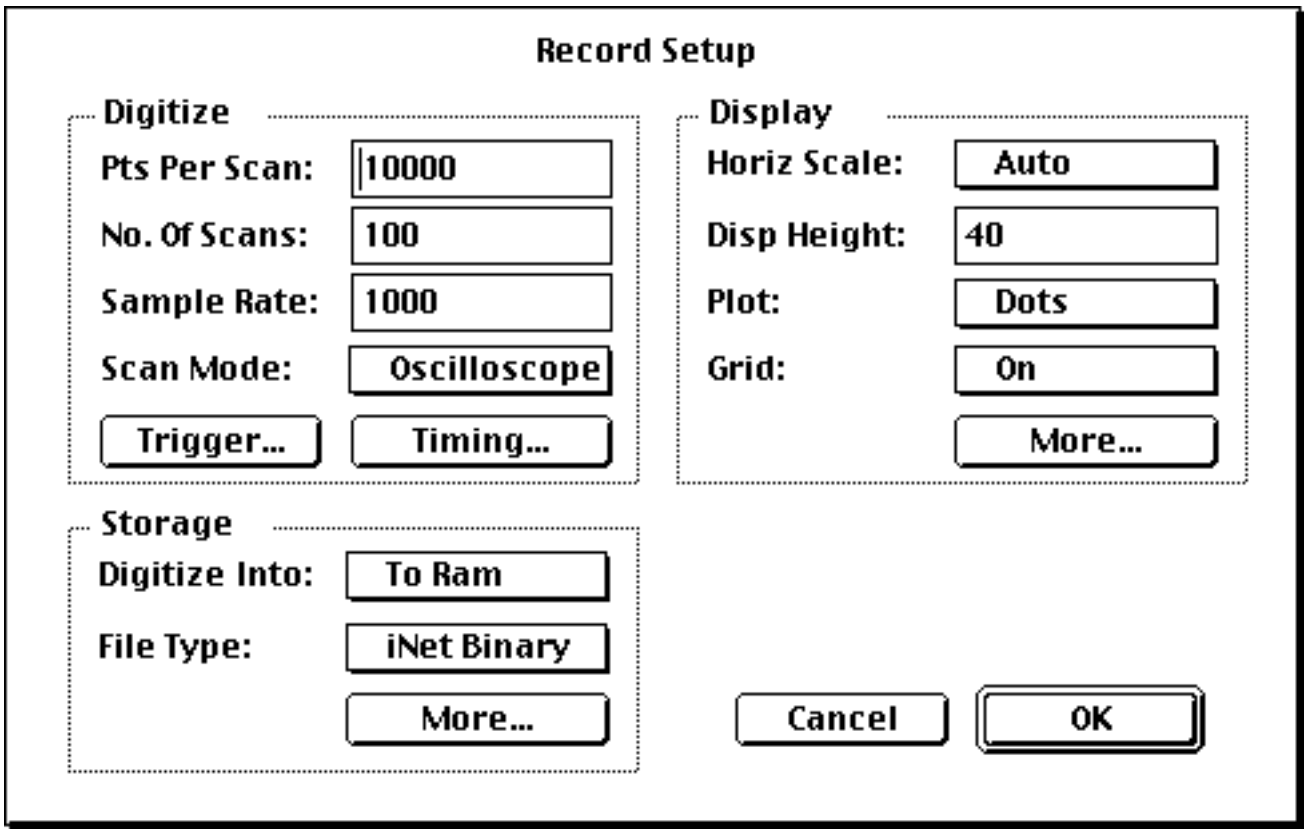


Figure 2.1 The Setup Dialog

The Setup dialog is used to set the base sample rate, the number of points to be acquired per Scan, the number of Scans to be acquired and the recording mode (i.e. oscilloscope or strip chart recorder). All instruNet Networks are set up with one base sample rate (i.e. number of points digitized per second) and individual channels can have sample rates less than or equal to the base sample rate. This allows, in effect, each channel to have its own sample rate.

The Sample Rate field sets the base sample rate. The Pts Per Scan field determines the amount of data to be collected in each Scan. The No. of Scans sets the number of Scans to be acquired. The Scan Mode popup has three choices: Strip Chart, Oscilloscope, and Oscillo Queued. Strip Chart is selected for continuous strip chart recorder mode and Oscilloscope or Oscillo Queued are selected for oscilloscope mode. Refer to the *Oscilloscope or Strip Chart* section of *Chapter 5* for a full description of these modes. The Digitize field is used by programmers.

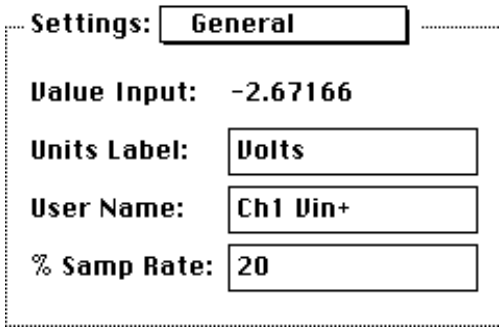
instruNet Networks are self-configuring and on startup determine the maximum rate at which data can be transferred. This rate is displayed after pressing the Timing button, in the Network BPS field, in units of bits per second. 4 million bits per seconds is the fastest, and 100Kbps is the slowest. This rate slows down with networks that have many Devices and long network cables (i.e. >100ft).

- Select Oscilloscope in the Scan Mode popup and set the Pts Per Scan field to 100. 100 points at 1000s/sec will take .1 seconds to acquire. Leave the rest of the Dialog in its default settings, and click OK to return to the Record Page.

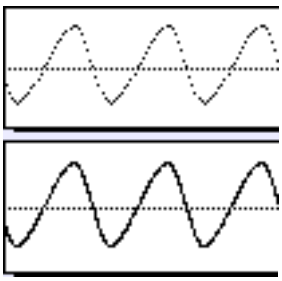
- Click the Start button to begin digitizing.

Notice how 0.1 second long waveforms continuously appear on the screen, in a manner similar to an Oscilloscope. Before, we were in Strip Chart mode where these segments were continuous with respect to each other. We are now in Oscilloscope mode. To learn much more about digitizing, please refer to the Record page discussion in *Chapter 5, instruNet World Reference.*

- Click the Stop button to stop digitizing, and then click on the top display's channel name label at the right edge of the display. The Display dialog will open. Choose General in the Settings popup. Enter the value 20 in the % samp rate field as shown to the right and press OK.



This will cause the top channel to be digitized at 20% of the master sample rate, or 200s/sec. The channel in the lower displays will continue to run at the master sample rate of 1000s/sec.



- Click the Start button to begin digitizing, and then click Stop after a few moments.

  Notice how the wave in the top display contains fewer points, due to its reduced sample rate, as illustrated to the left.

- Click the Setup button at the top of the Record page, and then click the Trigger button to open the Trigger dialog, as shown in Figure 2.2.

Trigger Modes

instruNet World allows triggering from any channel on either a low-to-high or high-to-low transition through a threshold value. The threshold is specified in the Thresh EU field, and the trigger direction is specified in the Slope field (i.e. low-to-high, or high-to-low). The channel to trigger from is specified by its network address in the Trig Net#, Trig Dev#, Trig Mod# and Trig Chan# fields.

Three trigger types are allowed, as specified in the Trigger field: Off, Auto and Norm. If Off is selected, data acquisition begins as soon as the Start button is pressed in the Record Page. If Auto is selected, data acquisition begins after the trigger criteria is met, but if the trigger condition is not met within a second or so,

the recording begins anyway. If Norm is selected, instruNet waits until the trigger condition is met, indefinitely of necessary.

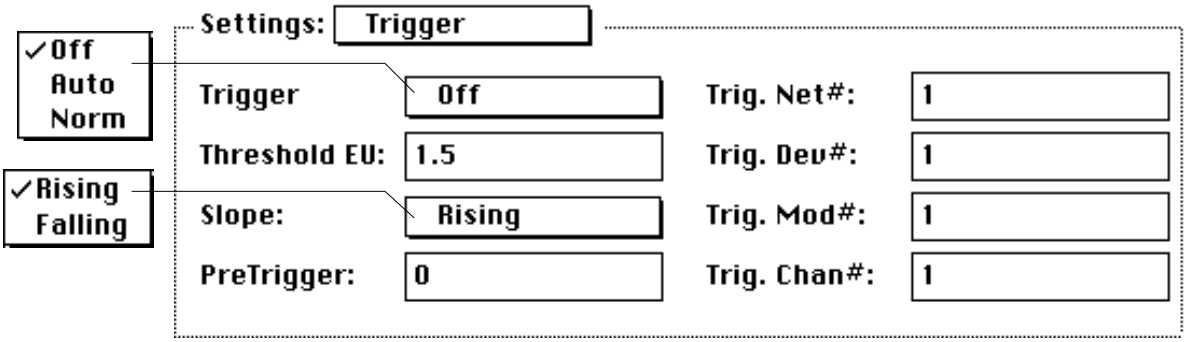
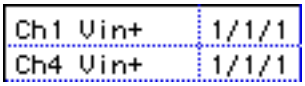


Fig 2.2 The Trigger Dialog



- Enter the address of a channel to trigger from into the Trig Net#, Trig Dev#, Trig Mod# and Trig Chan# fields. If you are not sure of a channel's address, go back to the Network Page and look at the Channel and Addr column for the channel you want to trigger from. The address for the two channels shown in the above figure would be {1,1,1,1} and {1,1,1,4}. For example, if you wanted to trigger from channel Ch4 Vin+, you would enter the following values: 1 into Trig Net #, 1 into Trig Dev#, 1 into Trig Mod#, and 4 into Trig Chan#.

- Select Auto in the Trigger popup, type a reasonable threshold voltage into the Threshold EU field (e.g. 1V) and then select Rising or Falling in the Slope popup. Click OK to exit the Trigger Dialog, click OK to exit theSetup Dialog and then click the Start button to begin recording.

The waveforms should appear on the screen, with the beginning of each Scan synchronized to the trigger event. If the signal applied to the trigger channel does not periodically cross the threshold voltage, Auto trigger will digitize anyway every second or so.

- Press Stop when you are done acquiring.

To learn more about Triggering, please refer to the Record page discussion in *Chapter 5*.

- Click the Setup button at the top of the Record page to open the Record Setup dialog, as shown in Figure 2.1.

Display Options

The Horiz Scale field sets the display horizontal scale in seconds-per-division. If set to Auto, instruNet picks a horizontal scale that is appropriate based on the sample rate and number of data points being acquired. The Disp Height field sets minimum height of each display in the Record page, in pixels. If the number of waveforms being digitized is greater than the available space on the screen, only a subset are displayed, and a vertical scrollbar selects that set. The Plot popup is used to set the drawing mode to plot Dots or Lines (i.e. light one pixel for each data point, or connect these data points with lines), and the Grid popup selects whether or not to overlay a grid on each display.

Digitize Into Ram or File

The Digitize Into popup has 2 primary settings: To Ram Buffer, which saves digitized data into RAM; and To File, which digitizes data directly to disk. If Digitize Into is set to To File, instruNet automatically prompts the user for a folder name every time a recording session is initiated with the Start button. The waveforms are then saved to this folder while they are recorded. One can then scroll through these long disk-based waveforms (e.g. 20M points per channel) via the horizontal scrollbar. Any waves saved to disk using the To File option can be opened and scrolled through with the Record Page's Open button.

The File Type field determines the file format for the saved data, and is set to one of Binary, Binary Merge, Text, or Text Merge. For a detailed description of each format, please see Appendix V, Working with instruNet Files.

- Select Lines in the Plot popup, select Off in the Grid popup, select "Strip Chart" in the Scan Mode popup and, set the Pts per Scan field to 10000 to set the buffer size of an intermediate RAM buffer that holds data before it is sent to disk (10000 points at 1Ks/sec is a comfortable size). Set the Digitize Into popup to "To File", and select 0.5 secs/div in the Horiz Scale popup. Click OK to exit the dialog. Click Start to begin recording. When the File save dialog appears, type a folder name and select a location for the waveforms that are about to be "spooled" to disk.

- After a minute or so, press the Stop button to stop digitizing. Scroll through your waveforms via the horizontal scrollbar. Notice that the computer goes to your hard disk periodically to automatically load in information from disk.

RAM-Based Digitizing

It is recommended that one Digitize Into RAM if your RAM is large enough. RAM based digitizing is easier, since data in RAM can easily be saved in different file formats, is easily loaded back into RAM from disk to be saved to disk in another file format, and supports faster digitizing rates. Due to these advantages, we recommend digitizing directly To Ram unless your RAM is not large enough to hold the data. To digitize into RAM, set the Digitize Into field to "To Ram Buffer", set the No Of Scans field to 1, and then use the Pts Per Scan field to determine how long you digitize. If you digitize multiple scans directly To Ram, data is overwritten in the RAM buffer and lost; therefore, we set the No Of Scans field to 1. After digitizing into RAM one can press the Save button in the Record page to save the data in the RAM buffer to disk in the format specified by the File Type field. To transfer data to another software package, one typically sets File Type to "Text Merge". This causes a file named "Merged.txt" to be saved to disk that is easily opened by a spreadsheet, with each channel in its own column. To save RAM based data in a compact fast format, we recommend File Type "Binary Merge". To calculate the amount of RAM used to hold your data, mulitply the number of points, by the number of channels, by 4bytes-per-point. For example, 3 channels of 10K points each would consume 120KBytes of RAM (120KB = 4 * 3 * 10000).

File-Based Digitizing

It is recommended that one Digitize Into File for bigger-than-RAM data, yet one must consider how they will process the huge disk-based file. To Digitize Into File, set the Digitize Into field to "To File", set the File Type field to "Binary Merge", set the Sample Rate field to the desired points-per-second-per-channel, set the Pts Per Scan field to a nominal value (e.g. 5000) to set the intermediate RAM buffer size, and then set the No Of Scans field to the number of RAM buffers of data that are collected. For example, digitizing 1000 scans of 5000pts-

per-scan data digitized at 1000pts-per-sec will spool to disk a total of 5M points over a 5Ksec period. When the Start button is pressed in the Record page, it will prompt you for a file name before digitizing, and send the data directly to disk.

The main issue, when digitizing directly To File is, "How are you going to deal with all that data on disk?". instruNet World will not allow you to load it into ram (since file based data is typically too large to fit into ram) and then save it back out in another file format. It will only allow you to scroll though and view the data (it automatically pages in segments from disk, as needed, for display). And to digitize To Disk quickly, you need to use the Binary Merge File Type, which interlaces all channels into one file, in 32bit floating point form. There is physically no other way to spool to disk at fast rates without saving in this manner. Therefore, to process a large disk based stream, one typically needs a software package that interprets 32bit floating point interlaced data. For details on this file format, please Appendix V.

To learn more about Setup Options, please refer to the Record Page discussion in *Chapter 5*.

- Try various options and settings to gain some familiarity with the wonder world of instruNet World. Some things to try are listed below:

  - Press the Start button to start recording again.
  - Press the Save button to save the digitized waves to disk (if they are RAM based).
  - Press the Open button to load previously recorded waveforms from disk.
  - Press the Setup button to adjust the sample rate and number of points that are digitized when the Start button is pressed.
  - Press the Trigger button within the Setup Dialog to adjust the trigger options.
  - Press the Network tab to select the Network page, and then turn on other channels for digitizing by clicking on their digitize on/off cells.

The instruNet Data Tree

instruNet stores field settings in a hierarchical data tree illustrated in figure 2.4.

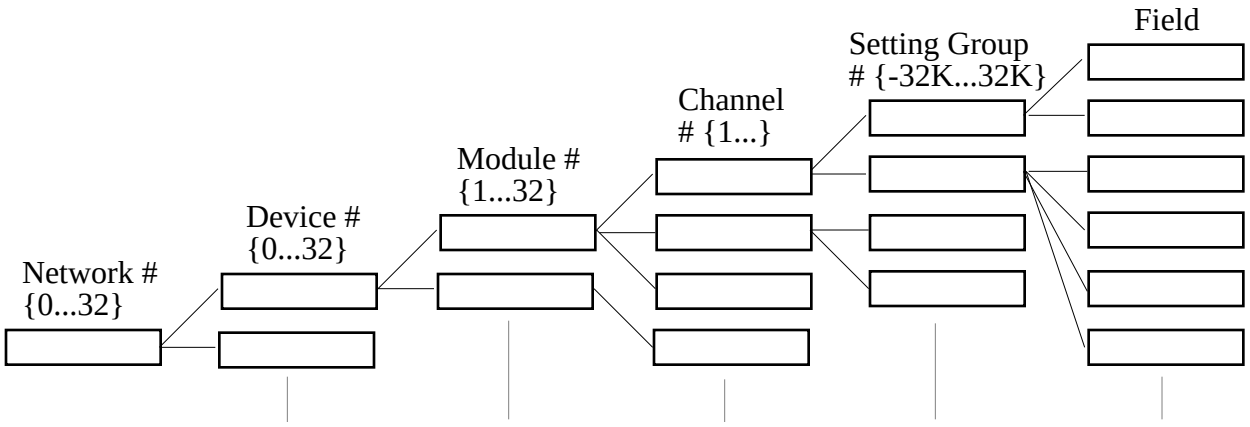


Figure 2.4 Network Hierarchy for instruNet

To access a piece of information, you must supply an address within this data tree. This address consists of 6 parameters, as described below:

Network Number If 0, this refers to the Driver itself (e.g. plot lines or dots in the Record displays); otherwise, this number refers to an instruNet Controller board, where the first board found in the computer is designated Network Number 1, the 2nd board found is Network #2, etc.

Device Number This refers to hardware devices (e.g. Model 100) attached to an instruNet Controller board, where the hardware Device closest to the Controller is Device #1, the next device is Device #2, etc.

Module Number This refers to the module within a hardware device. At this time, all Devices have only 1 module that is referred to as Module #1.

Channel Number This refers to a specific channel in a hardware device. Each channel typically corresponds to a physical wire somewhere, such as a voltage input, voltage output, digital input, or digital output. For example, in the Model 100, the screw terminal marked "Ch1 Vin+" is Channel #1 and is a voltage input.

Setting Number Each channel includes different Settings areas such as: lowpass filter settings, highpass filters settings, Hardware settings, etc. It is here that one selects a settings group (e.g. Lowpass Filter fields have a Settings Number of -9).

Field Number This is the Field Number {1..8} within a settings group. For example, in the Lowpass Filter settings group, the cut-off frequency in Hertz is stored in Field #5.

The instruNet World user navigates within this data tree via the Probe dialog, described in the next discussion. instruNet World does not require the user to know about Setting numbers and Field numbers since all items are defined using popups and edit fields. The programmer, on the other hand, must supply 6 numbers to a subroutine to read and write to any field on the instruNet data tree.

The Network page shows the current Field settings for each channel in a tabular (i.e. spreadsheet) format, and is also a useful tool for navigating around the instruNet data tree. The data tree maintains any changes you make until you Reset the network via the Reset button, reset the computer, or load in new setting from disk via the Restore or Open buttons at the top of the Network page. In many cases, a user will set the fields as needed, stored them to disk, and then reload them when instruNet world is first opened.

Explore Your World

- Run instruNet World if it is not already open.

- Select the Network page by pressing the Network tab at the bottom of the window.
- Press the Reset button at the top of the window to reset all Fields in the Data Tree. Press OK when a dialog asks for confirmation.

Figure 2.5 illustrates how information is organized in the Network page. The channels that are displayed on your computer will vary depending on what hardware is installed; therefore, don't worry if your screen is a little different from the Figures.

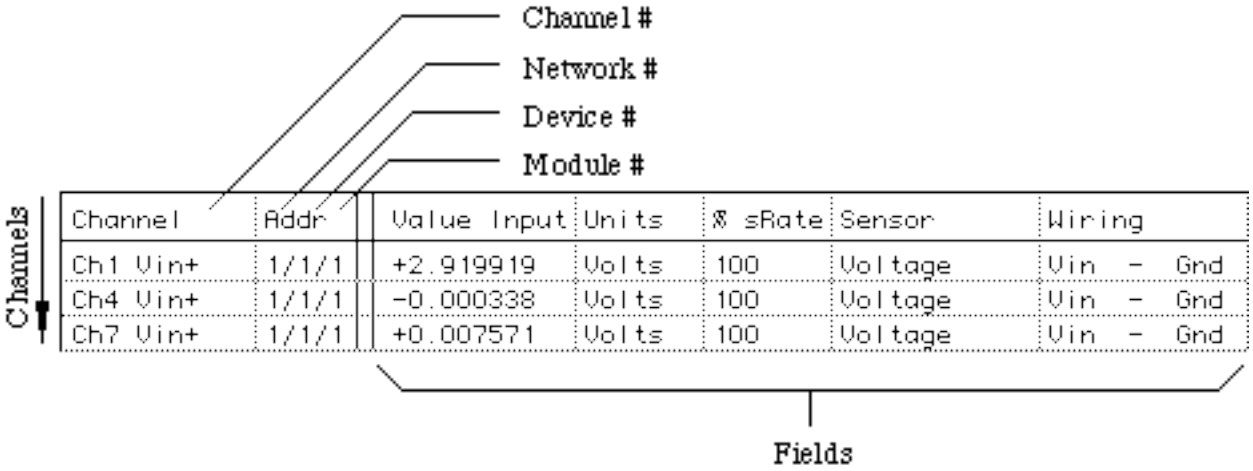


Figure 2.5 Partial view of the Network Page

The Network Page

Each row in the Network page corresponds to an input or output channel, which is often associated with a physical sensor in the real world. Each channel has a {Network, Module, Device, Channel} address both within the software data tree and the physical outside world. This address is shown in the first 4 columns of the Network page. The first column indicates the Channel name and number. For example, "Ch1 Vin1+" is Channel #1 and the channel name is "Ch1 Vin1+". Columns #2 through #4 indicate the channel's Network #, Device # and Module #, which correspond to a physical address.

The column labeled "Value Input" depicts the current real-time value (input or output) of the channel, in engineering units. All columns to the right of the Value Input column are Fields that specify the type of signal connected to the channel and how it is being read. The horizontal and vertical scroll bars are used to move around and make changes to the tables contents. To change a Field's setting, one can click on its cell and then change its value. For example, to change the name of channel Ch1 Vin1+, one would click on the "Ch1 Vin1+" cell.

- Click on any cell in the Units Label column to open the Probe dialog, as shown in figure 2.6.

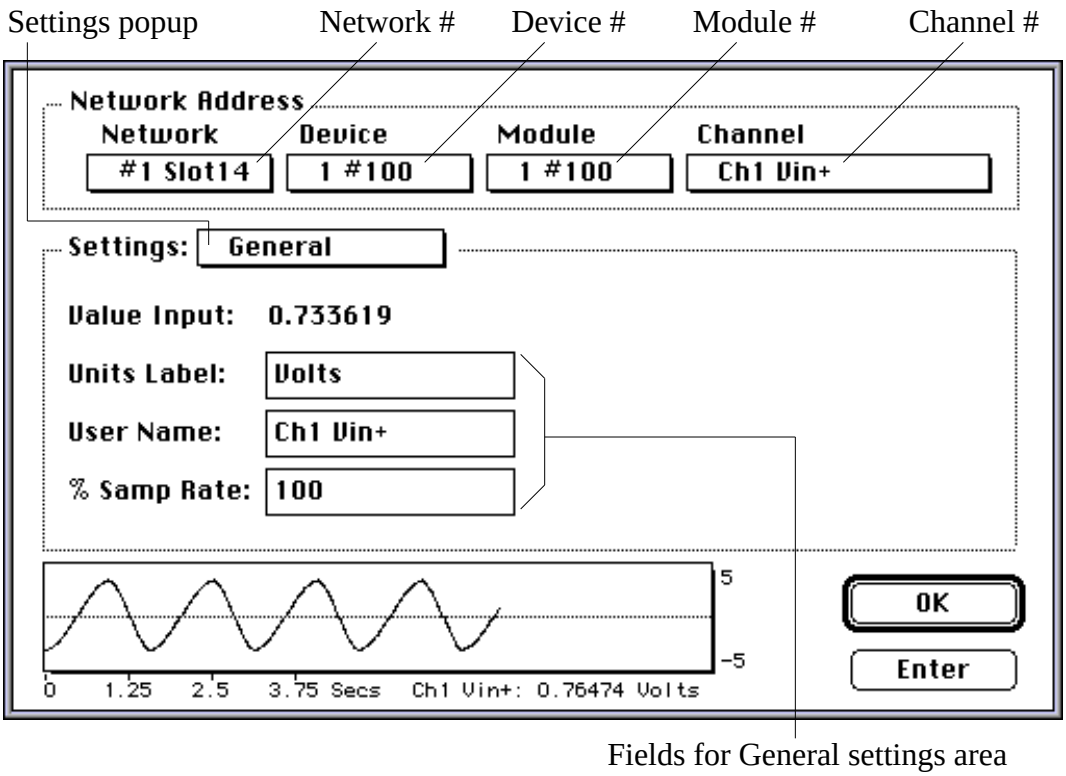


Figure 2.6 The Probe Dialog

The Probe Dialog

Using the Probe dialog, any Field within the instruNet Data Tree can be viewed or modified. The upper-most 4 popup menus specify a channel address (i.e. Network, Device, Module, Channel), the Settings popup specifies a Setting group (e.g. General, Lowpass Filter, Highpass Filter, etc), and the Settings area shows between 1 to 8 Fields depending on the Settings group selected.

For example, in Figure 2.6, we are viewing the General settings for channel Ch1 Vin+, which is physically connected to the 1st Device (a Model 100) attached to the 1st Controller (i.e. Network), which is plugged into computer slot #12. The General settings group contains 4 Fields: Value Input, Units Label, User Name, and % Sample Rate.

The Value Input field shows the real-time, current value, of the channel, Units Label is the displayed label for the channel's value (e.g. "Volts", "Amps", "C"), User Name is the user's name for the channel (e.g. "Temp 1", "Pressure 2", etc), and % Sample Rate is the speed, as a fraction of the Master Sample Rate, that the channel is digitized (e.g. 50% would mean the channel is digitized at one-half the sample rate specified in the master Setup dialog). The small display at the bottom of the Probe dialog shows a plot of the current real-time value of the Channel.

- Click on the Units Label field and change "Volts" to "Amps". Click OK to exit the Probe dialog.

The clicked on cell should be update to "Amps", as shown in figure 2.7.

Channel	Addr	Value Input	Units
Ch1 Vin+	1/1/1	3.2143	Amps
Ch4 Vin+	1/1/1	-0.001557	Volts
Ch7 Vin+	1/1/1	+0.007571	Volts

Amps

Figure 2.7 Edited cell within the Network page

- Scroll through the Fields of the Network page using the horizontal scroll bar at the base of the window.

Notice that the first 5 columns remain fixed, while the cells to the right of Column #5 shift left and right with the horizontal scrollbar. You can scroll through, and view, all Fields for all Channels in this manner. Figure 2.8 shows the Network Page for Ch1 Vin+ after scrolling a little to the right.

Channel	Addr	Range	Ro	Rshunt
Ch1 Vin+	1/1/1	+- 5V	100	5000

Figure 2.8 Network Page scrolled horizontally to view the Ro & Rshunt Fields

- Scroll horizontally to the left edge so that "Value Input" is in Column #6 and then scroll vertically until an input channels is no longer in the top row. For example, in Figure 2.9, a Voltage Output channel is in the top row.

Notice that the title to Column #6 changed from Value Input to Value Output. This is because the titles are optimized for the one channel in the top row.

Channel	Addr	Value Outpu	Units
Ch12 Vout	1/1/1	+0.013493	Volts
Ch15 Vout	1/1/1	+0.013740	Volts

Figure 2.9 Network Page scrolled vertically to view the title for voltage outputs.

- Vertically scroll to the top of the table and then click on the net cell of the first row. (it should contain a 1) This will cause the Probe dialog to open and to display the clicked on cell.

Channel Addresses

The upper region of the Probe Dialog, shown in Figure 2.10, is used to select a Channel's address (i.e. Network Number, Device Number, Module Number, and Channel Number).

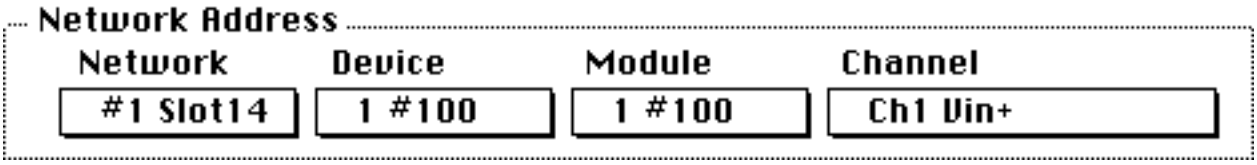
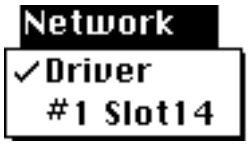
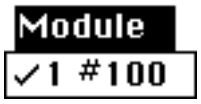


Figure 2.10 Network Address Configuration section of Probe Dialog

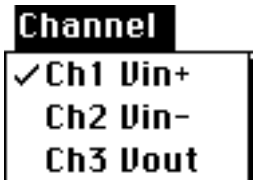


When instruNet World resets (e.g. powers on), the expansion slots in the computer are scanned for instruNet controllers. Each controller found is given a Network Number. For example, in Figure 2.10, instruNet World found a controller in Slot 14 of a computer and designated the network connected to it as Network #1. Hence the popup reads #1 Slot 14. This popup enables the user to select any instruNet controller installed on the computer. There is a special "Controller" in the popup that is labeled "Driver" (Network #0). This refers to the instruNet Driver itself, and appears only once in the Network popup no matter how many Controllers appear. The Driver contains fields that determine things like the way displays show data in the Record page.

The Device popup menu lists the network Devices that are attached to the Controller specified in the Network popup menu. When you select a Controller in the Network popup, all devices attached to it appear in the Device popup. In the figure shown to the left, only one network device is attached to the Controller in Slot 14 and it appears as the second item in the popup. It is a Model 100 and is designated Device #1 (1 #100). The Controller itself is a Device (Device #0) and appears as the first item in the Device popup. The Controller contains Fields that are specific to the controller, such as the network sample rate, or the value of a digital output on the Controller's Digital I/O Connector.



The Module popup lists all Modules in the currently selected {Network, Device}. Most Devices only have 1 module, as shown to the left.



The Channel popup lists all analog and digital I/O channels in the currently selected {Network, Device, Module}. The illustration to the left shows 3 channels, 2 of which are voltage inputs, and the 3rd which is a voltage output.

- Explore your instruNet world via the 4 Channel Address popup menus at the top of the Probe dialog, and the Settings popup menu. Press OK when you are done exploring.

Saving & Loading Network Settings

All instruNet Fields (i.e. all the cells in the Network page) are saved to disk and loaded from disk with the press of a button. When a configuration is saved, all information including items such as trigger conditions, sample rates and channel units are stored. Waveform data is not stored at this time, but can be saved by pressing the Save button in the Record page. When a configuration is loaded, all items are restored to their previously saved condition. This means that instruNet configurations for specific experiments only need to be set up once. And once a configuration is loaded, it can be changed and then saved again if needed, possibly in a different file.

- Select the Network page by clicking the Network tab.

The first two buttons at the top of the Network Page, Restore and Store, work as a pair. Clicking the Store button saves the current network settings to a preferences file within your operating system folder. Clicking Restore loads in this file. File open and save dialogs do not appear, since the Fields are always saved to the same file (i.e. a file with the same name). Obviously, you loose your last saved network when you press the Restore button (careful !).

- Press the Store button to save your current Field settings to disk.

- Press the Clear button to erase your Field settings to their default values.

Notice how the "Amps" units label has now returned to its default setting of "Volts".

- Press the Restore button to restore the previously saved settings.

Notice how the "Amps" units label has returned. To save the settings to the file of your choosing, click the Save and Open buttons.

- Press the Save button . Type a file name and select a file location when the File Save dialog appears. Remember where you put this file.
- Now press the Clear button to clear all settings to their default values.
- Press the Open button and select your saved file in the File Open dialog.

Notice how the "Amps" units label now appears. At this time, you have 2 files on your hard disk with your saved network settings.

The Reset button differs from the Clear button in that it resets the hardware in addition to clearing your fields. It has the same affect on an instruNet network as restarting the computer. For example, Reset will reset clock in the controller, whereas Clear will not.

Working with Sensors

Any voltage input channel can attach to any of the following sensors: Voltage source, Current source, Resistance source, Strain Gage, RTD, or types J, K, T, E, R, S, B, and N Thermocouples. Sensors can be wired in a variety of configurations including: Differential Voltage Measurement (requires 2 voltage input channels, e.g. Ch1 Vin+ and Chi Vin-), Single-ended Voltage Measurement, Shunt Resistor, Voltage Divider, Bridge, Quarter Bridge and for strain gages: Half-Bridge Bend, Half-Bridge Axial, Full-Bridge Bend, Full-Bridge Axial I and Full-Bridge Axial II.

- Select the Network page by clicking on the Network tab.
- Click on the name of the voltage input channel with the attached signal source (e.g. "Ch1 Vin+").

The Probe dialog will open with the address of the channel you clicked on displayed in the Network Address. Additionally, the real-time value of the channel, in Engineering Units (EU) will appear at the bottom of the display, as shown in Figure 2.11.

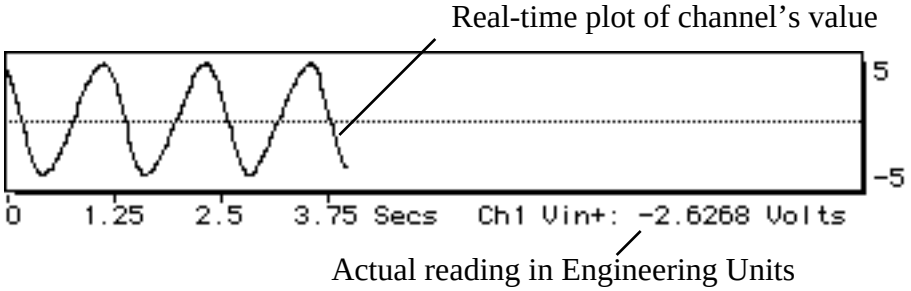


Figure 2.11 The Snapshot Display

- Select Hardware in the Settings popup, as shown in Figure 2.12.

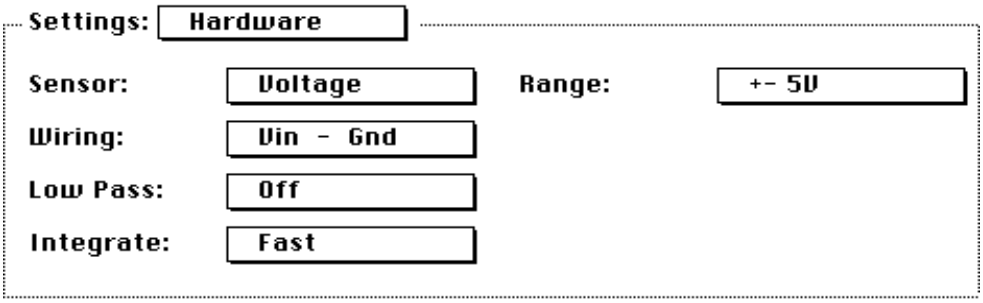
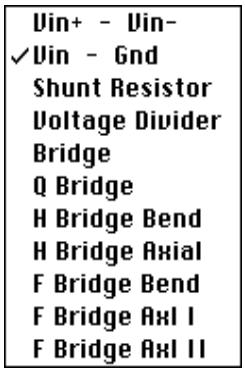


Figure 2.12 Hardware Settings Area

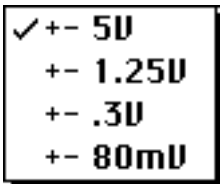
- Click on the Sensor popup to view the various Sensors that can directly be attached to this channel, as shown to the right.

This popup tells instruNet which sensor is connected to your physical hardware terminals (instruNet has no way of seeing what is out there). For more detailed information on connecting sensors to instruNet, please refer to *Chapter 3 Connecting to Sensors.*



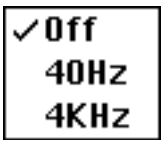
- Click on the Wiring popup and view the choices, as illustrated to the left.

The Vin+ - Vin- option is used for differential Voltage measurements to measure the voltage between the Vin+ and Vin- terminals. The "common" signal on both terminals is ignored, and therefore this technique can be used to reduce noise. The Vin+ - Gnd option specifies Singled-Ended voltage measurement, which measures the voltage between the voltage input terminal and the Ground terminal. The latter 6 options (Q Bridge, Half Bridge Bend, Half Bridge Axial, Full Bridge Bend, Full Bridge Axial I and Full Bridge Axial II are used to specify a wiring options when working with a Strain Gage sensor. These wiring options are described in more detail in Chapter 3.



- Click on the Range popup and view the options, as illustrated to the left. Select the largest range (e.g. +- 5V).

This Field specifies the voltage input range. Accuracy is increased as the range is reduced. For example, a +-80mV range might be accurate to +-100uV, whereas a +-5V range might only be accurate to +-2mV. If you input a voltage in excess of a bound, the bound is read. For example. If you apply 3V a voltage input with a +-1.25V range, then +-1.25 will be read by the computer.



- Click in the Low Pass popup and view the options, as illustrated to the left.

The options that you see will depend on the connected hardware device. This Field is used to select an analog filter at the front end of the voltage input amplifier. Please consult *Chapter 6, Hardware Reference* to learn more about the analog filter options for each hardware Device.

The Integrate field specifies how long, in Seconds, instruNet averages an input signal before 1 number is returned to the user. This is often used to reduce high frequency noise that has been added to a signal. The integration feature is implemented by sampling the signal many times with the A/D converter, as fast as it can, and then averaging the A/D values with software. The maximum allowable integration time depends on the number of digitized channels and the sample rate. For example, 2 channels could be sampled at 1000s/sec per channel and integrated each for .5ms.

- Select Constants in the Settings popup, as illustrated in Figure 2.13.

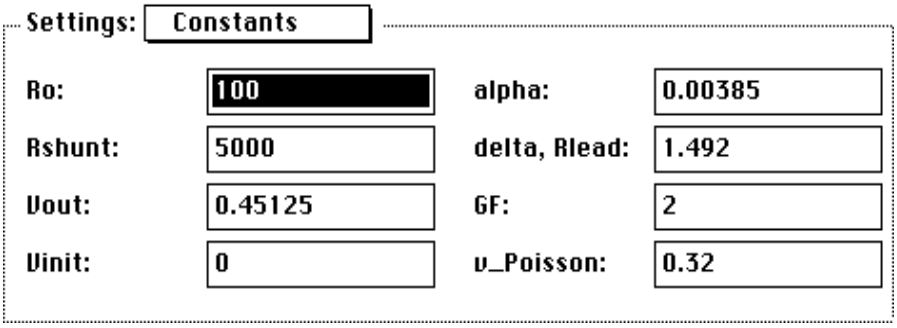


Figure 2.13 Constants Settings Area

These Fields are used to specify constants that are used to calculate engineering units when working with Resistance, Current, RTD, and Strain Gage sensors. For example, Rshunt specifies the value of the shunt resistor, in ohms, when doing a Resistance measurement. Please refer to Chapter 3 for details on how to use these.

- Click OK in the Probe Dialog to return to the Network page.

- Enable the first three voltage input channels for digitizing by clicking once on Column #5 of each channel, as illustrated in Figure 2.14.

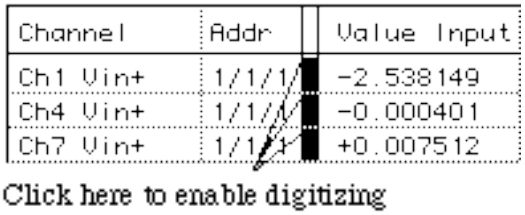


Figure 2.14 First 3 channels of Model 100 are enabled for digitizing.

- Select the Record page by clicking on the Record tab at the bottom of the window.

- Click the Start button to begin recording.

The Record Page automatically creates a separate display for each recorded channel, as shown in Figure 2.15. The actual signal that appears will depend on the connected signal sources.

- Click the Stop button to Stop recording.

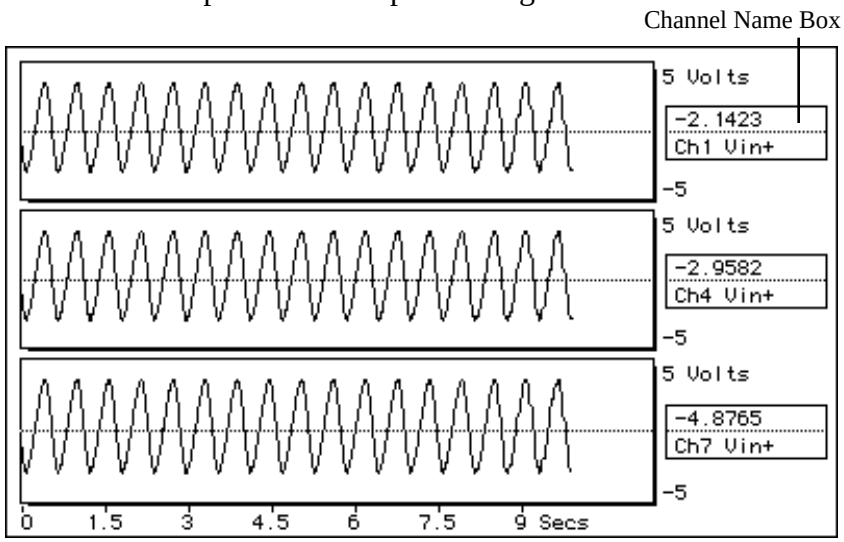
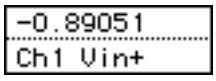


Figure 2.15 Three Channels in Record Page



Each display has a Channel Name box which appears to the right of the display, as shown to the left and in figure 2.15. This box displays the channel name and the real-time channel value in Engineering Units.

- Click on the Channel Name box of the top-most display to open the Probe dialog at the Display settings area, as show in Figure 2.16.

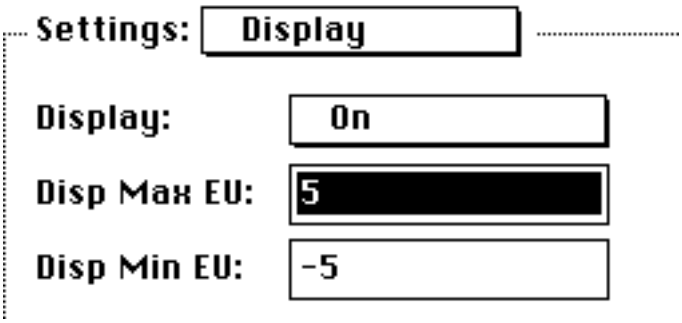


Figure 2.16 Display Settings

- Change the Disp Max EU Field to 2, change the Disp Min EU Field to -2, and click the lower-right Enter button.

These 2 Fields are used to set the top and bottom plot values of the vertical axis in both the Record page display and the Probe dialog snapshot display. These changes take affect when the Enter button is pressed, and can be viewed at the bottom of the

Probe Dialog, as shown in Figure 2.17. In many cases, one must edit these values, depending on the Engineering Unit range of the digitized signal. For example, one might set 0 and 100 for a temperature that ranges from 0 to 100C.

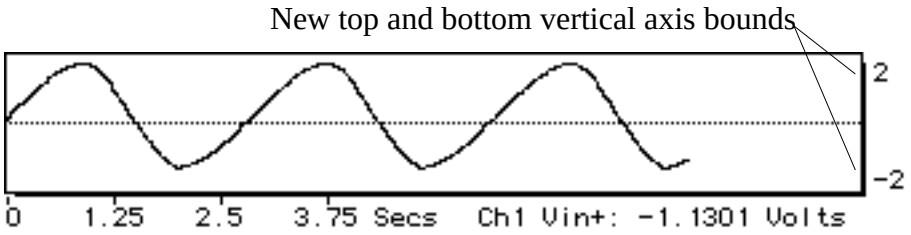


Figure 2.17 Probe display with E.U.'s set to +/- 2V

- Press OK to exit the Probe dialog, and then press Start to begin recording.

Notice how the vertical axis scale change effects the appearance of the recorded signal, as shown in Figure 2.18.

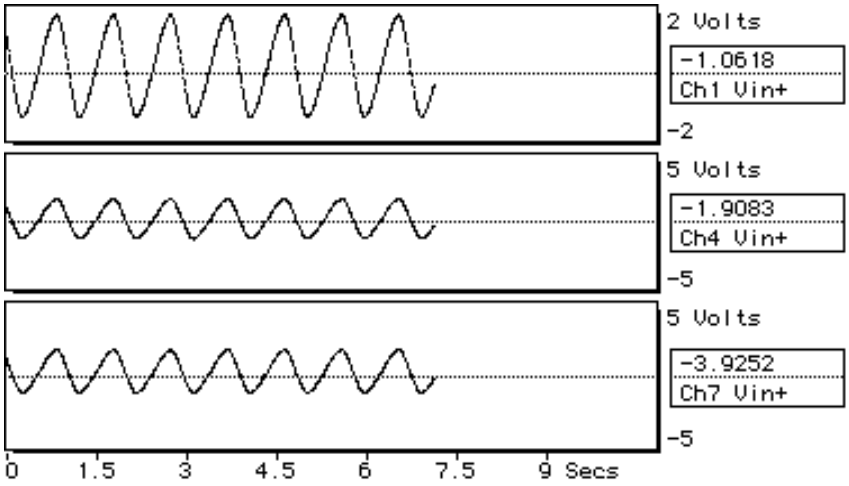


Figure 2.18 Record Page with top display Min/Max E.U. set to +/- 2V

Working with instruNet BASIC

instruNet BASIC enables users to automate the setting up of channels, digitizing, viewing results, and saving to disk. It is predicated on the BASIC programming language, and features many additional commands that facilitate working with instruNet hardware. instruNet BASIC builds on the instruNet World strip chart recorder by automating common tasks done at experiment time. This is especially helpful at reducing the chance of error, and making the data taking process more pleasant. A person who is not too familiar with the computer, doing many manual steps, at a fast pace, under pressure, can lead to a problem. instruNet BASIC addresses that issue by consolidating a series of steps into one button press in the instruNet World window. For details concerning this powerful language, please see *Chapter 9, instruNet BASIC*.

Simple Example

- Press the BASIC tab at the base of the window, to select the BASIC page, which is used to develop and execute instruNet BASIC code.

The BASIC text editor is used to create, edit, view, execute, and test instruNet BASIC files, which are based on standard text files, and appear as regular unformatted text.

- Please type the following into the window:

```
Delete Buttons
NewButton BASIC "Print 3x"
      For c! = 1 to 3
            Print (channel(1/1/1/1))  "\r"
      Next
EndButton
End
```

- Press the Execute button to execute the code. A button should appear at the top of the window entitled, "Print 3x".

- Press this button, and notice how the value of channel 1/1/1/1 (i.e. Channel #1, from Network #1, Device #1 and Module #1) is printed three times.

- Press the Save button to save your code to disk in a text file.

The first line of your program, "Delete Buttons", causes all previously created buttons to be deleted, so they do not accumulate each time you run this program. The NewButton command creates a new button in the BASIC page with the name "Print 3x". The code between NewButton and EndButton executes when "Print 3x" is pressed. This button causes a loop to execute 3 times, via the For statement. The body of the For loop is a simple print statement that prints the value of channel 1/1/1/1 and a carriage return character.

Congratulations! You have now completed your first program.

Benefits

What can instruNet BASIC do for ME ?
instruNet BASIC can create more text editor pages within instruNet World for data and notes, each with their own tab at the base of the window. And BASIC can easily print notes and data to these pages, save the text to disk, and load text from disk. Also, with several lines of BASIC code, one can spool digitized data to disk in one large text file, filling a 2 GByte file at rates of approximately 5000 points/second. instruNet BASIC can also create buttons at the top of the instruNet World window that execute BASIC code when pressed. Buttons can be used to set up the calibration of channels, record data, save data, and view data. instruNet BASIC can declare a list of channels, that are many channels long, and then with one line of code, globally set a field (e.g. sensor type, wiring, integration) for each of those channels. This enables one to set up channels without manually setting fields within the instruNet Network page. For more details, please see the text files in folders "instruNet\ BASIC\ Examples\ ", and "instruNet\ BASIC\ Documentation\". One can read these by pressing the BASIC tab at the base of the instruNet World window, pressing the Open button, and then navigating to the instruNet\ BASIC\ directory.

DVM Example

- Press the Open button, navigate to file "instruNet\ BASIC\ Examples\ DVM.iBs", and load the file into the instruNet BASIC text editor.
- Press the Execute button to run this program, and press the Stop button when done monitoring its activity.

This program reads several channels and prints them to one line in the text editor, once each second, simulating a digital voltmeter.

Math Example

- Press the Open button, navigate to file "instruNet\ BASIC\ Examples\ MathExp.iBs", and load the file into the instruNet BASIC text editor.
- Press the Execute button to run this program.
- Scroll up and down to review the various math-oriented features.

MathExp.iBs demonstrates many mathematical functions, bitwise operators, logical expressions, string functions, and time related features.

Print Example

- Press the Open button, navigate to file "instruNet\ BASIC\ Examples\ Print.iBs", and load the file into the instruNet BASIC text editor.
- Press the Execute button to run this program.
- Scroll up and down to review the various print and string related features.

Data Acquisition Example

- Press the Open button, navigate to file "instruNet\ BASIC\ Examples\ TakeData.iBs", and load the file into the instruNet BASIC text editor.
- Press the Execute button to run this powerful program.

This code creates a new page called "Data", creates several buttons for this new page, and selects the new page.

- Press the BASIC tab at the base of the window to return to the original code, and then press the Data tab to return to the new data taking page.
- Press the Setup button to set up several channels, per the TataData.iBs Setup button code.
- Now press the Record button to digitize data into the Data page. Hold the mouse down to stop the data taking after several lines have been printed.

This program shows how instruNet BASIC can set up channels, record into a text editor, and spool a large 2Gbyte file to disk (via the Spool button).

To Learn More

The "instruNet\ BASIC\ Examples\ ..." directory contains many simple example programs. To learn more about instruNet BASIC, please load and run several of these examples, and also see *Chapter 9, instruNet BASIC*.

Working With Calibration, Different Scales, & Mapping

instruNet supports Calibration and Converting to different scales (e.g. show psi at sensor instead of Volts at screw terminals) with a 2 point mapping scheme. All channels have a Mapping settings area that defines the relationship between "internal units" and "external units". Internal units are the native units used by instruNet, such as Volts. External units are what the user sees in the Record page, the Network page, and the numbers returned by iNet(). External units are linearly mapped to Internal units, and are therefore defined with 4 numbers, that define 1 line ($\{x_1,y_1\}$, $\{x_2,y_2\}$), on an Internal Units Vs. External Units 2-dimensional coordinate axis plane.

Sounds a little complicate? Imagine a linear temperature sensor that puts out .1Volts when dipped in ice water (0°C) and 1Volts when dipped in boiling water (100°C); and you want instruNet to display °C numbers in the Record page and the Network page. To do this, one would set the Mapping fields to:

$internal_1$: .1 (Volts)	$internal_2$: 1.0 (Volts)
$external_1$: 0 (°C)	$external_2$: 100 (°C)

And set the Units Label field in the General Settings area to "C". The Units Label does not effect instruNet numerically, yet is interpreted as random text that is simply placed next numbers (i.e. it is a "label"). The Mapping fields; however, effect numbers, yet not labels.

The Mapping numbers can also be used to implement calibration. Suppose a thermocouple (i.e. temperature sensor) is attached to instruNet and is already returning °C numbers (since that is the native units for the thermocouple), yet you find there is a 2°C offset error in your sensor, and want instruNet to "correct" for this error. To do this, the user would set up a mapping from internal units to external units that reflected the offset error. e.g.

$internal_1$: 100 (°C)	$internal_2$: 0.0 (°C)
$external_1$: 102 (°C)	$external_2$: 2.0 (°C)

Notice that Mapping can be used to correct for an offset error by adding a constant and can correct for a gain error by multiplying by a constant.

The Mapping setting area describes a line using two different methods: two points "$\{x_1,y_1\}$, $\{x_2,y_2\}$", and "y = x*scale + offset". One can use either method. For example, instead of setting the above 4 values, one could have set the Offset field to 2.0, to show a 2°C Offset. When the Scale or Offset fields are changed, the x_1,y_1,x_2,y_2 fields update automatically to reflect the new line when the OK or Enter button is pressed.

Working with Digital Filters

All voltage input channels support digital lowpass, highpass, bandpass and bandstop filters. The cut-off frequencies, minimum dB stopband attenuation (i.e. filter order), maximum dB passband attenuation, and filter type (e.g. elliptic, Chebyshev B, Chebyshev S, and Butterworth) can all be programmed separately for each channel via the Lowpass, Highpass, Bandpass and Bandstop Settings areas. In fact, these 4 models can be run at the same time (i.e. in serial) to simultaneously do lowpass, bandpass, bandstop and highpass filtering on the same channel. For example, one might only want to see frequencies between 20 and 1000Hz, except for the 55 to 65 band. This would involve a highpass filter at 20Hz, a bandstop filter between 55 and 65Hz, and a lowpass filter at 1000Hz.

- Select the Network page by clicking on the Network tab and then press the Reset button to reset the network and all Fields.

- Click the channel name cell of the channel that is attached to your signal source (e.g. Ch1 Vin+), and then select Lowpass in the Settings popup, as shown in Figure 2.19.

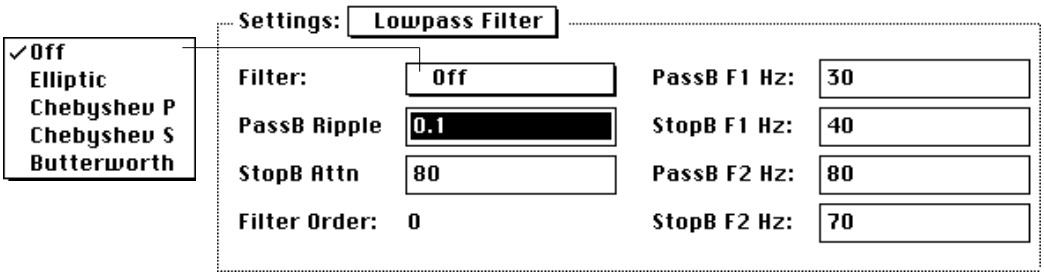


Figure 2.19 Lowpass Filter settings area

The lowpass filter is illustrated in Figure 2.20. Notice that 4 numbers are needed to describe the lowpass filter: minimum stop band attenuation (dB), maximum pass band ripple (dB), pass band cut-off frequency (Hz) and stop band cut-off frequency (Hz). And notice how these 4 numbers corresponds to the StopB Attn, PassB Ripple, PassB F1 Hz, and StopB F1 Hz Fields in the Lowpass Filter settings area.

- Turn the filter On by selecting Elliptic in the Filter popup (or any of the other options other than Off).

- Enter a passband cut-off frequency value into the PassB F1 Hz field, a stopband cut-off frequency into the StopB F1 Hz field, a minimum stop band attenuation into the StopB Attn field, and a maximum pass band ripple into the PassB Ripple field. Acceptable values would be {100, 150, 80, 1}. Press the Enter key when done setting the values. If the filter is impossible to design due to constraints of the specified values, an alert will appear with a message coaching the user into selecting different parameters. In fact, instruNet will not allow you to exit this dialog until the parameters are acceptable, or the filter has been turned off by selecting Off in the Filter popup.

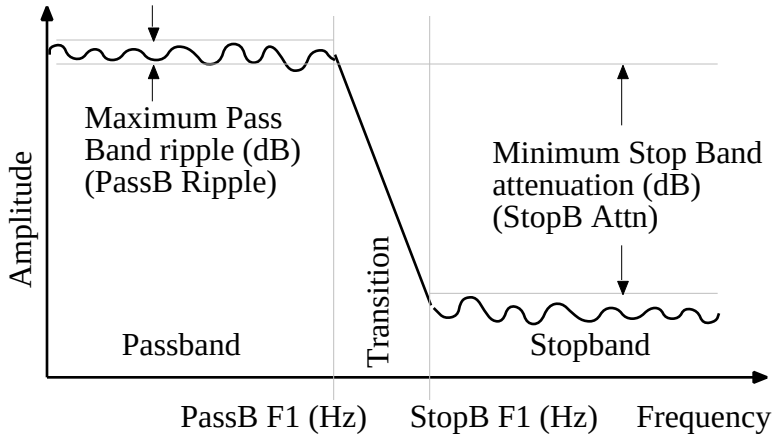


Figure 2.20 Lowpass Filter Model

The filter order ranges from 1 to 32 in bandpass and bandstop filters, and from 1 to 16 in highpass and lowpass filters, depending on the supplied parameters. As the filter becomes more demanding, the filter order increases, and the time to run the filter also increases. In a typical case, it takes .1 to 2us per order per point to run the filter. For example, on a Macintosh 840av (1993 technology) it takes 2us per order per pt or 20us per point to implement a 10th order filter. This would limit the maximum sample rate to 50Ksamples/second (i.e. 1 / 20e-6 = 50e3).

- View the results of your filter by observing the effect it has on the waveform in the Snapshot display. If you have a function generator connected, watch what happens when you slowly change its frequency from 10Hz to 500Hz, for example.

Figure 2.21 shows a 35 Hz signal applied to Ch1 Vin+, before and after the implementation of a 30 Hz lowpass filter.

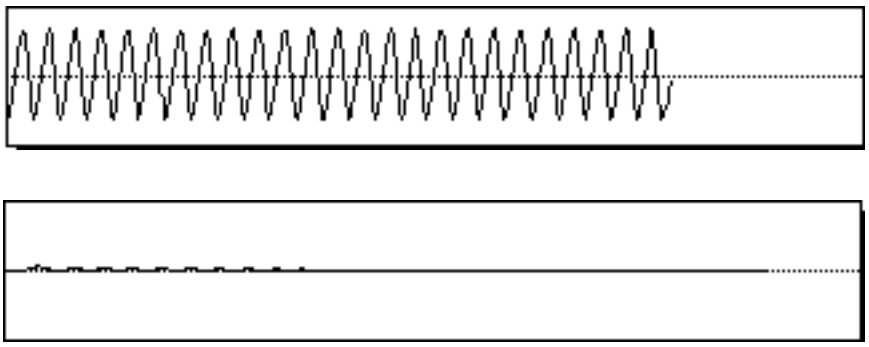


Figure 2.21 35 Hz Sine Wave before and after 30 Hz Lowpass Filter

Figures 2.19 through 2.21 show the filter models for the Highpass, Bandpass and Bandstop filters.

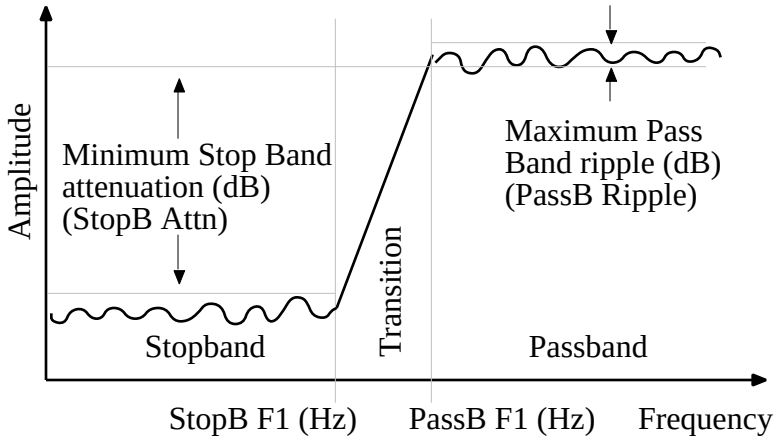


Figure 2.22 Highpass Filter Model

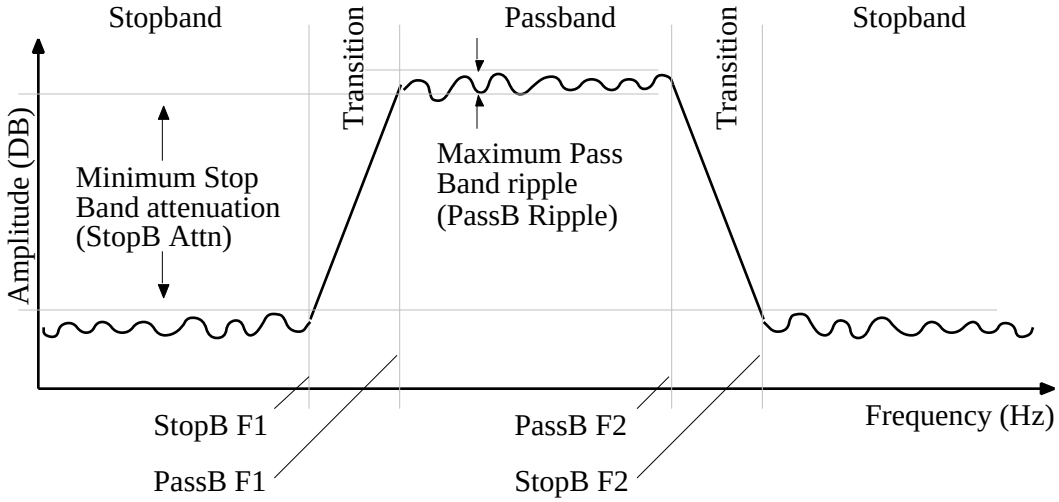


Figure 2.23 Bandpass Filter Model

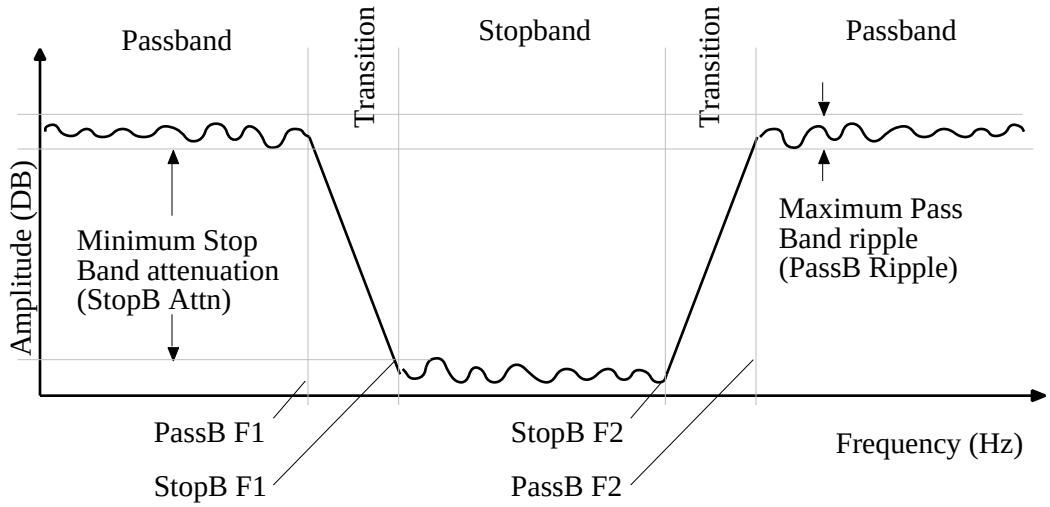


Figure 2.24 Bandstop Filter Model

Table 2.1 shows which fields in the Settings area must be set for each filter model.

Edit field or popup	Lowpass	Highpass	Bandpass	Bandstop
Filter popup	used	used	used	used
PassB Ripple	used	used	used	used
StopB Attn.	used	used	used	used
PassB F1 Hz:	used	used	used	used
StopB F1 Hz:	used	used	used	used
StopB F2 Hz:	not used	not used	used	used
PassB F2 Hz:	not used	not used	used	used

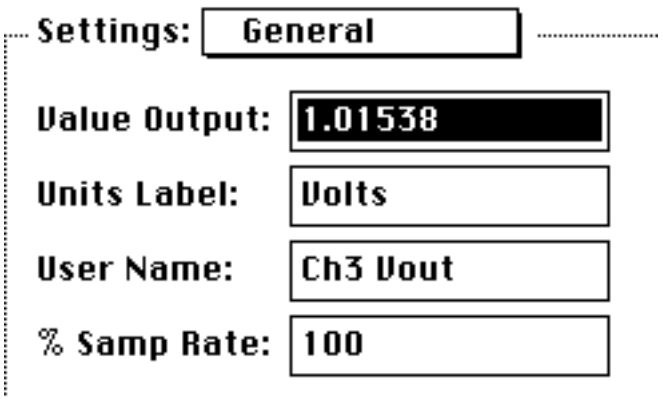
Table 2.1 Fields required for each Filter model

- Play with the different filter models and settings while viewing their effects in the snapshot display. For example, to turn on a highpass filter, select Highpass Filter in the Settings popup, select Elliptic in the Filter popup, and then set the PassB F1 Hz, StopB F1 Hz, StopB Attn, and PassB Ripple fields as desires using Figure 2.19 as a guide. Remember to press the Enter button to create the filter.

Working With Voltage Output Channels

Some hardware devices, such as the Model 100, provide Voltage Output channels. In summary, these channels output the Voltage specified in the Value Output field within the General settings area. Accuracy's are discussed in *Ch6, Hardware Reference*. Voltage Output channels are named ChX Vout in the Network Page.

- In the Network page, click on the 1st cell of the first voltage output channel. For the Model 100, this would be the "Ch3 Vout" channel. When the Probe dialog opens, set the Value Output field to 1, and press the Enter button, as illustrated to the right.



The analog output channel is immediately updated to the new value when Enter is clicked.

- Click OK to return to the Network page and view the Value Input column for the chosen Voltage output channel. It should display a value in the vicinity of 1V.

With Voltage outputs, instruNet reads back the output voltage and displays this value in the Value Out column. This is useful information when loading of the output signal will change its value. An example of this is a bridge excitation circuit where it

is important to know the value of the excitation voltage within a small margin (e.g. to ±.01%) yet the actual voltage only needs to be within several percent of the target voltage.

Working With Digital I/O Channels

Some hardware Devices provide Digital I/O channels. For example, the Model 100 Device offers 8 bi-directional digital I/O bits where 8 different terminals physically marked "DIO1..DIO8" can be set up independently as either a digital input or digital output. With the Model 100 digital outputs, 0 to .8V is a logic 0, and 2V to 5V is a logic 1; however, with the Model 100 digital inputs, 0 to 1V is a logic 0, and 3.2V to 5V is a logic 1. Also with these signals, voltages above 12V or below -12V will result in physical damage (careful !). These 8 hardware bits are all handled by 1 instruNet channel named "Ch25 Dio", where the 8bits are read from or written to with a 1 byte word (i.e. 8 bits in a number between 0 and 255).

To set digital output bits, such as those on the Model 100, it is necessary to do the following kinds of things:

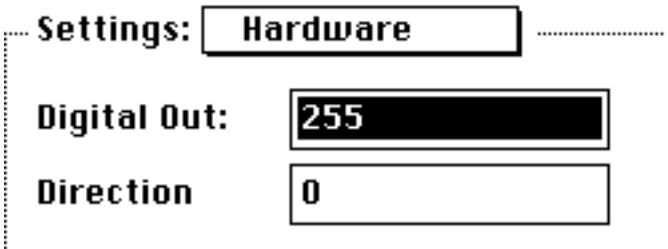
- Click on the cell that contains the name of a Digital I/O Channel (e.g. "Ch25 Dio") and select Hardware in the Settings popup menu.

The Direction field specifies the bit direction, where a value of 1 specifies output, and 0 specifies input. This field packs the 8bits into one 0 to 255 number, where d0 corresponds to DIO1, d1 corresponds to DIO2, etc. For example, $4_{10} = 00000100_2$ would specify DIO3 as an output, and the rest of the hardware bits are inputs. A Direction value of $0_{10} = 00000000_2$ specifies all hardware bits as inputs, and a value of $255_{10} = 11111111_2$ specifies all bits as outputs.

The Digital Out field is used to set the state of the bits that have been marked as outputs by the Direction field. It does this with one 0 to 255 number where each bit in the byte sets its corresponding hardware bit. For example, if 8 bits were set up as outputs, then a Digital Out value of $17_{10} = 00010001_2$ would set DIO1 and DIO5 to a logic 1, and the rest to a logic 0.

The Value EU field in the General settings area is used to read the states of the 8 bits via a 0 to 255 number where each bit in the received byte corresponds to a hardware bit. For example, reading $3_{10} = 00000011_2$ would mean that hardware bits DIO1 and DIO2 are high, and the rest are low.

- Set the Digital Out field to $3_{10} = 00000011_2$, set the Direction field to $1_{10} = 00000001_2$ and click the Enter button to update the bits.



- Select General in the Setting popup menu and note the value displayed in the Value EU field.

Value EU should show $253_{10} = 11111101_2$. This is because the high 6 bits have been set up as digital inputs in the Direction field, and if nothing is connected to them, they will float high to a logic 1. DIO1 is set up as an output in the Direction field, and has been set to a 1 in the Digital Out field, and is therefore read as a 1. DIO2 has also been set up as an output in the Direction field, yet has been set to a 0 in the Digital Out field, and is therefore read as a 0.

Working With Controller Digital Timer I/O Channels

The Model 200 and 220 (not 230) instruNet Controller boards have 10 digital input/output channels, each of which can be used for period measurement, clock output, digital input or digital output. Each of these channels runs independently of the others, and of the other channels on the network.

For example, "Ch1 Timer" is the first channel in a controller board. Its network address is Device 0, Module 1, Channel 1; and its physical location is two pins on a 34 pin header connector located on the controller board. The two connector pins are labeled "Ch1 Din" and "Ch1 Dout", one for digital input and one for digital output. With the controller digital outputs, 0 to .8V is a logic 0, and 2V to 5V is a logic 1; however, with the controller digital inputs, 0 to .8V is a logic 0, and 3.5V to 5V is a logic 1. Also with these signals, voltages above 6V or below -6V will result in physical damage (careful !). An instruNet Field is used to specify the function of Channel 1 as digital input, digital output, clock output or period measurement. If digital input or period measurement are chosen, the "Ch1 Din" pin is used; otherwise, the "Ch1 Dout" pin is used.

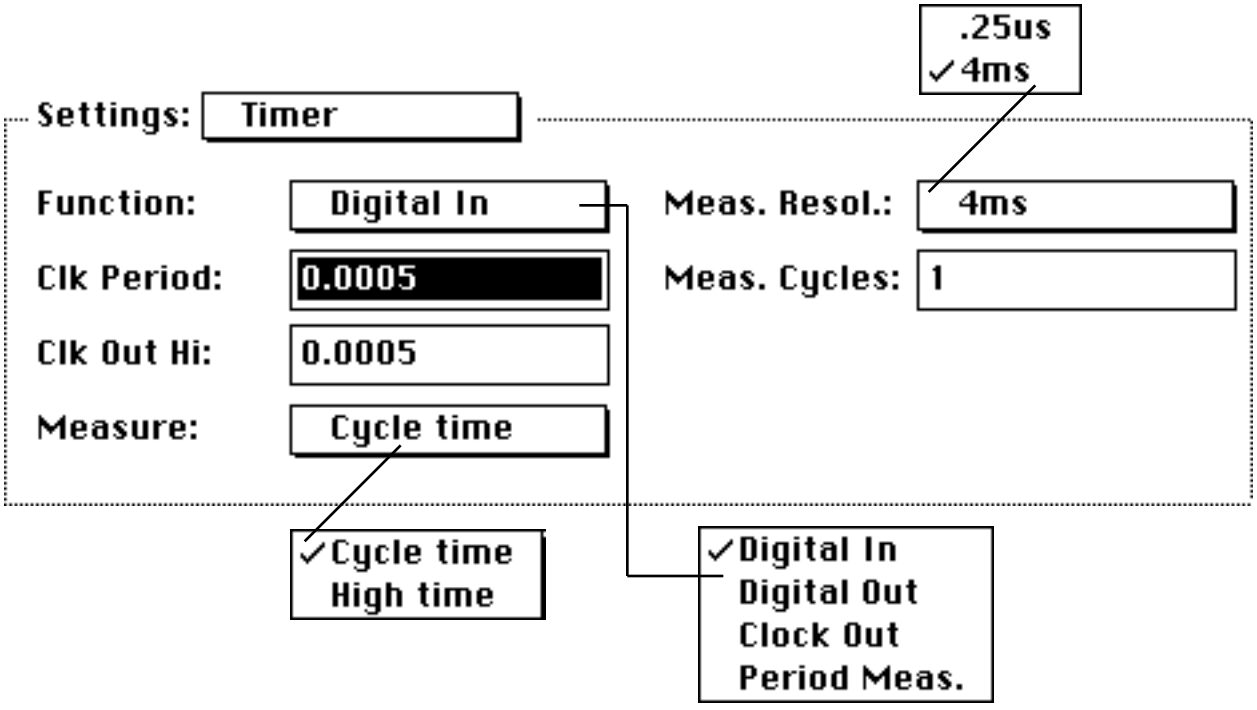


Figure 2.25 The Timer Settings Area

Physically, all controller channels are accessed at a 34 pin header connector (.025" square pins with .1" spacing) located on the Controller board. This connector is independent of the DB25 Connector that is used to cable to the network Devices. One typically cables to this connector via a 34-wire ribbon cable that terminates outside the computer at a screw terminal panel. Please refer to *Chapter 1 Hardware Installation* for details on cabling, and *Chapter 6 Hardware Reference* for details on each pin within this connector.

- Select the Network page by clicking the Network tab, and then click in Column #1 of the first controller's Ch 1 Timer channel (you might need to scroll down a little). When the Probe dialog appears, select Timer in the Settings popup, as illustrated in Figure 2.25.

The Function popup selects the channel's Function to be one of Digital Input, Digital Output, Clock Output or Period Measurement Input, as described below:

Digital Output — The "Ch*X* Dout" connector pin is set to a logic 0 (0-.8V) if the Value I/O field in the General settings area is set to a 0; otherwise, this pin is set to a logic 1 (2V-5V).

Digital Input — The Value I/O field in the General settings area is read as 0 if the "Ch*X* Din" connector pin is held by an external source below .8V (otherwise, it floats to 5V). However, if this pin is above 3.5V, it is read as a 1.

Clock Output — A square wave clock signal is driven out of the "Ch*X* Dout" connector pin where the cycle time is specified by the Clk Period field, in units of seconds, and the high time is specified by the Clk Out Hi field, in units of seconds.

Period Measurement — The duration of the signal applied to the "Ch*X* Din" connector pin is measured and returned in the Value I/O field of the General settings area, in Seconds units. If the Measure field is set to Cycle time, the time is measured between consecutive falling edges; otherwise the time is measured between a rising edge and the next falling edge. The Meas Cycles field varies from 1 to 255 and sets the number of cycles (or high times) that must occur over the measured duration. For example, measuring 10 cycles of a 1KHz square wave would return 10ms; whereas measuring 5 high times of a 20KHz square wave would return 125us. If the Meas Resol popup is set to .25us, the measurement is accurate to .25us and the falling-edge-to-falling-edge time (or rising-edge-to-falling-edge) must range from 3us to 16ms. Otherwise, if the Meas Resol popup is set to 4ms, the measurement is accurate to 4ms and the falling-edge-to-falling-edge time (or rising-edge-to-falling-edge) must range from 12ms to 576 secs.

Table 2.2 shows which Fields are used for each of the different functions. instruNet ignores settings not needed for a particular function. For example if Digital Input or Digital Output is selected in the Function popup, instruNet ignores all other Fields in the Timer area.

Field	Digital In	Digital Out	Clock Out	Period Meas.
Clk Period	not used	not used	used	not used
Clk Out High	not used	not used	used	not used
Measure	not used	not used	not used	used
Meas. Resol.	not used	not used	not used	used
Meas. Cycles	not used	not used	not used	used

Table 2.2 Fields used with different Controller Digital I/O Functions.

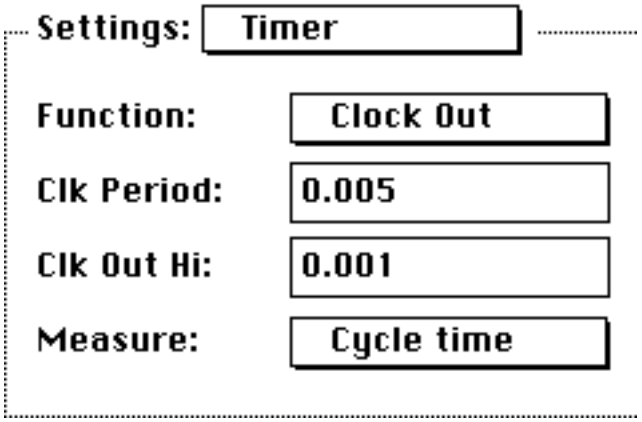
We will now set up one channel as a clock output and measure its duration with another channel. This will require a 34 wire screw-terminal block cabled to the digital connector on a Model 200 or 220 instruNet Controller board. If you do not have a screw terminal block wired to your Controller, you can still do this experiment, yet the measured period will not be correct.

- Connect a physical wire between Pin #6 (Ch1 Dout) and Pin #7 (Ch2 Din) of the Controller Digital I/O connector.

- Set the Function popup to Clock Out, the Clk Period field to .005, and the Clk Out Hi field to .001.

- Select General in the Settings popup and set the User Name field to "Clock Out".

- Click the Enter button in the bottom right of the Probe Dialog to start the clock output.



- Select Ch2 Timer in the upper-right Channel popup to select the 2nd channel in you instruNet Controller.

- Set the User Name field to "Clock Meas".

- Select Timer in the Settings popup.

- Set the Function popup to Period Meas, set the Resolution popup to .25µs, set the Measure popup to Cycle Time, and set the Meas Cycles field to 1; as shown in figure 2.25.

- Press OK to return to the Network page.

Clock Out	1	0	1	
Clock Meas	1	0	1	0.005

Notice how the names of your first two Controller channels have changed to "Clock Out" and "Clock Meas", and how Clock Meas's Value field is displaying .005 seconds of measured period. This is the period of the clock signal being output by Ch1 Timer and being measured by Ch2 Timer. If you remove the wire connecting the Output of Ch1 Timer and the input of Ch2 Timer, the Value field will change.

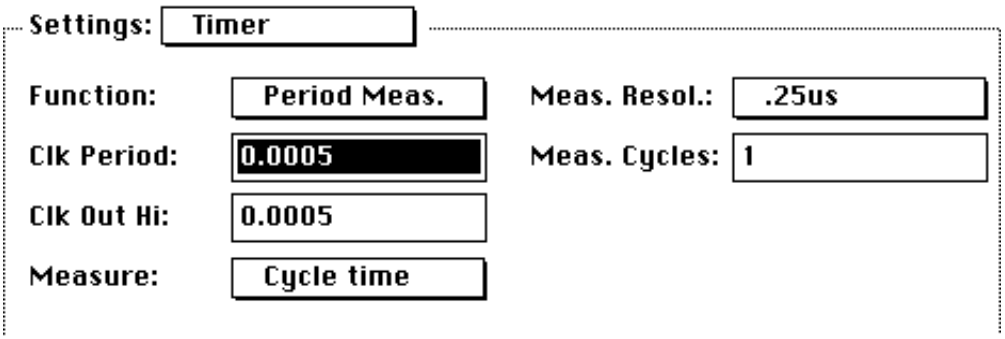


Figure 2.25 Timer Settings for Period Measurement

Working With The Controller Time Since Reset Channel

The instruNet Controllers offer a channel that provides the time, accurate to .25us, since the Controller was last reset. A reset occurs when instruNet is first used after power up, the computer resets, and when the Reset button is pressed in the Network page. This clock channel is called "Ch12 Time" and returns a number in units of seconds that is derived from a 62bit counter that counts 4MHz.

- Select the Network page by clicking the Network tab, and scroll down until you see the Controller's Ch12 Time channel. Notice how the Value cell slowly increments at a 1 second rate.

Working With Multiple Controllers

instruNet supports multiple controllers (i.e. networks) in one computer. In this case, the meaning of the "network number" becomes more important, since it selects a particular network in the data tree from which to operate. To digitize simultaneously from multiple controllers, one must select channels for digitizing in the Network page (any channel combination across all controllers), and then press the Start button in the Record page. There is one complexity however, which is that each controller has its own Trigger settings. This is because each controller operates independently (i.e. each has its own processor that manages its own data acquisition task). To access a Trigger dialog for a specific network, press the Trigger button in the Setup Dialog, and then select a specific network in the Network popup menu.

Setting the Trigger with multiple controllers is a little tricky since one controller cannot physically see the trigger signal attached to other controllers, and each controller has no way of sending messages to its colleagues in a short period of time. To make the digitizing from all networks trigger off the same signal, one must attach the trigger signal to one channel from each network, and set up the Trigger dialogs for each network to trigger off that one channel in each of their respective networks.

Triggering Off A Digital Input

To trigger off the instruNet 100 Ch25 Digital Input, specify this channel as the trigger source, attach your trigger signal to Ch25 DIO8, and set the trigger threshold to 200. When DIO8 is high (i.e. 2-5V), Ch25 is read as {128..255}; and when DIO8 is held low (i.e. 0-.8V) Ch25 is read as {0-127}.

Next Step

This concludes the tutorial. From here you might consider exploring the following areas: *Chapter 3, Sensor Reference*, which summarizes how to connect sensors; *Chapter 4, Programmers Tutorial*, which is a tutorial designed to get programmers up and running quickly.

3 Connecting to Sensors

This chapter describes how to connect sensors to instruNet hardware and how to configure instruNet software for each type of sensor. instruNet allows different sensors to be connected directly to each input channel including RTD's, thermocouples, strain gages, resistance sources, current sources; and single-ended and differential voltage sources. In some cases, the user must add an external resistor to facilitate the reading of a sensor.

This chapter is not intended to be a complete reference on sensors and their use. For a wonderful reference and catalog of temperature and strain sensors, please call USA Tel 1-800-826-6342 (Fax 1-203-359-7700) and request a free copy of "The Temperature Handbook" & "The Pressure Strain and Force Handbook". instruNet supports a direct connection, returning native engineering units, to the following sensors:

Sensor	Units	Wiring	Constants	Figure #
Voltage	Volts	single-ended	none	3-1
Voltage	Volts	differential	none	3-2
Voltage	Volts	bridge	Vinit, Vout	3-2b
Current	Amps	shunt resistor	Rshunt	3-3
Resistance	Ohms	voltage divider	Rshunt, Vout	3-4
Resistance	Ohms	bridge	Ro, Rshunt, Vout	3-5
Strain Gage	Strain	voltage divider	Ro,Shunt, Vout, Vinit, GF	3-6
Strain Gage	Strain	Q bridge	Ro, Vout, Vinit, GF, Rlead	3-7
Strain Gage	Strain	H bridge bend	Ro, Vout, Vinit, GF, Rlead	3-8
Strain Gage	Strain	H bridge axial	Ro, Vout, Vinit, GF, Rlead, v_Poisson	3-9
Strain Gage	Strain	F bridge bend	Vout, Vinit, GF	3-10
Strain Gage	Strain	F bridge axial I	Vout, Vinit, GF, v_Poisson	3-11
Strain Gage	Strain	F bridge axial II	Vout, Vinit, GF, v_Poisson	3-12
RTD	Celsius	voltage divider	alpha, delta, Ro, Shunt, Vout	3-13
RTD	Celsius	bridge	alpha, delta, Vout, Vinit, Ro	3-14
J, K, T, E, R, S, B, & N Thermocouple	Celsius	differential	none	3-15
Thermistor	Celsius	voltage divider	Ro, Shunt, Vexe, Vinit, alpha, delta, GF, v_Poisson	3-16

Table 3.1, Sensors that can directly be connected to instruNet

Connecting a Sensor Directly to *instruNet*

The instruNet voltage input terminals (often labeled "Vin(+)" or "Vin(-)") can directly connect to a variety of sensors, with instruNet software returning values in native engineering units (e.g. degrees Celsius, strain, Volts, Amps, ohms). This requires wiring the sensor to the instruNet hardware in the appropriate manner, and then configuring the instruNet software for your particular sensor, as described in the following steps:

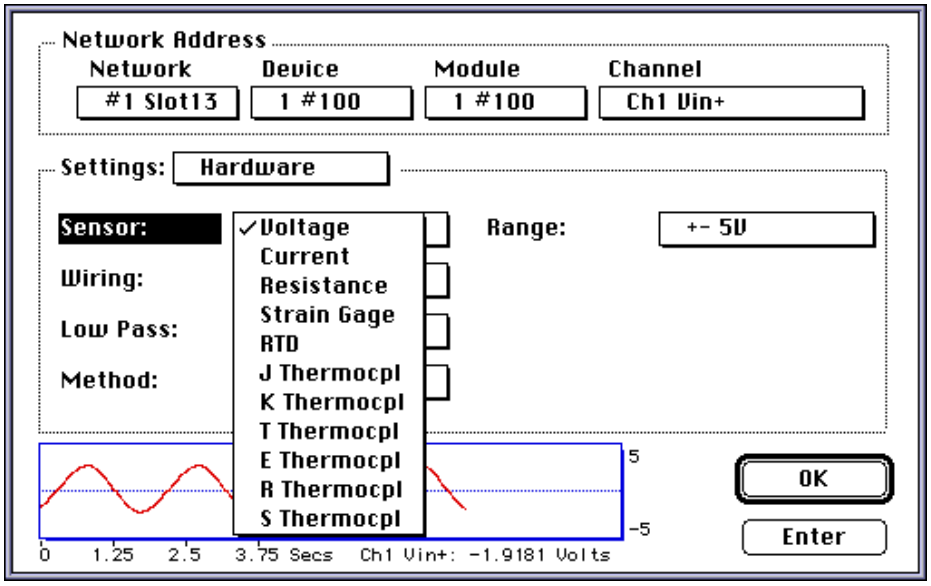
1) Physically Wire your Sensor to instruNet hardware

The first step is to physically wire your sensor to the instruNet hardware, per the Hardware Reference guidelines at the end of this chapter. Each sensor listed in the previous table is discussed in detail in this reference. For example, to connect a J Thermocouple, one would attach the positive lead of the thermocouple to the instruNet Vin+ terminal, and the negative lead to the Vin- terminal. The input terminals are protected against over voltage and electrostatic discharge, therefore it is not always necessary to power off network devices (e.g. Model 100) while wiring sensors, although turning power off is recommended as a good safety practice. If your sensor does not fit into one of the standard categories in the previous table, then you need to choose the closest category, and then do the calculations necessary to resolve your desired engineering units. If you do power OFF your network, please use the following sequence:

1. Power OFF powered devices connected to the Network
2. Power OFF Computer
3. Configure network cables, sensors, and devices
4. Power ON Computer
5. Power ON powered devices connected to the Network

2) Tell the instruNet software which Sensor is connected

Set the Sensor popup in the Hardware settings area of the Probe dialog to the correct Sensor (e.g. Volts, J Thermocouple, etc). The sensors to choose from are listed in the first column of the Sensor Hook-up Table, at the beginning of this chapter.

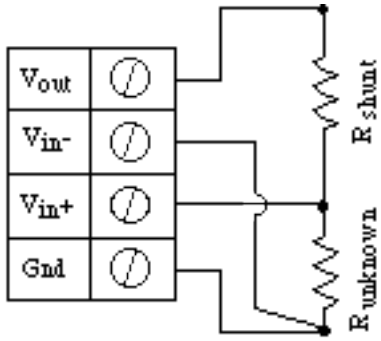


To set the Sensor popup, one would:

1. Open the instruNet World window by launching the Windows 95 "`instruNet World Win32.exe`" or Macintosh "`instruNet World Mac`" application program (e.g. double-click on its icon).
2. Click on the Network tab at the bottom of the window to select the network page.
3. Click on the name of your channel in the left-most column to open the Probe dialog.
4. Select Hardware in the Settings popup menu.
5. Select the desired sensor in the Sensor popup menu, as illustrated in the previous figure.

3) Tell the instruNet software how the Sensor is wired
Set the Wiring popup in the Hardware settings area of the Probe dialog to the correct Wiring (e.g. Single-Ended, Differential, Bridge, Voltage Divider, etc). Please consult the Sensor Hook-up Table, at the beginning of this chapter, for guidance. Recall that the chosen wiring popup must match your actual physical hardware wiring.

4) Set the appropriate constants as required
Set the fields in the Constants settings area as needed. This involves selecting Constants in the Setting popup, and then setting specific Constants fields as noted in the previous table. For details on specific sensors, please consult the Sensor Reference at the end of this chapter. For example, to measure a resistance instruNet needs to know the value of an external shunt resistor "Rshunt", in ohms, and the value of the excitation voltage "Vout", in volts, as illustrated to the right. This would involve setting the Rshunt and Vout Constants fields to correspond to your actual wiring. instruNet software would then automatically return an amplitude in "ohms" units after measuring the voltage at the Vout terminal, measuring the voltage between the Vin+ and Vin- terminals, and calculating the realtime $R_{unknown}$.



5) Select the appropriate input voltage range
Set the Range popup in the Hardware Settings area as needed. This selects a voltage range that is used by instruNet. If the voltage exceeds a bound, then the bound is returned by the software. For example, if you input 2V and the range is +/- 1V then instruNet will return 1Volt. The resolution and accuracy of the measured signal increases when the range is reduced. For example, with the Model 100, the voltage accuracy is 25uV in the +/-10mV range, and 1mV in the +/- 5V range with 1ms of integration. Some sensors require a specific voltage range, or only allow one range. For example, the range with thermocouples is always in the neighborhood of +/- 100mV.

6) Set the Integrate popup
Set the Integrate popup in the Hardware Settings area as needed. This selects the duration that the signal is averaged before instruNet returns one number. For example, if you choose 16ms, it will return the average signal value over a period of

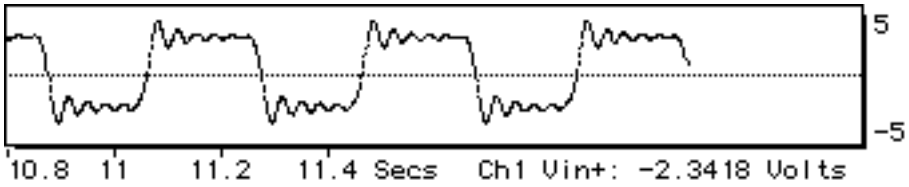
16ms. This is helpful at reducing noise for signals acquired at slow sample rates (e.g. to integrate 16ms worth of data the sample rate must be greater than 16ms per point, or slower that 60samples/second) Each hardware device offer different Integrate options.

7) Select the appropriate Analog Filter
Set the analog Low Pass filter popup in the Hardware Settings area as needed (e.g. off, 40Hz, 4KHz). Each hardware device offers different analog low pass filter options as described in *Ch 8, Hardware Reference* (not all devices support hardware analog filtering). Low pass filters cause high frequencies to be rejected, while low frequencies are passed. Visually, the signal becomes "smoother". To see the effects of various filters, view the digitized signal at the bottom of the probe dialog, after making different selections (you might not be able to do this until you are further along in the set up process).

8) Set your Digital filters as needed
If you need to do a digital low pass, high pass, band pass, or band stop filter on your digitized waveform, please set the fields in the filter Settings areas (e.g. Low Pass, High Pass) as desired. Digital filters are run on the waveform post acquisition, and only effect digitized waveforms (not single values read by instruNet). Please refer to Ch2 Tutorial, Setting Digital Filters for an expanded discussion of this powerful feature.

9) Consult the Sensor Reference for specifics
Carefully implement the Sensor Reference instructions for your particular sensor, later in this chapter, and read the corresponding footnotes at the end of this chapter. Different sensors require different range, filter, and constants settings; and care should be taken to insure accurate results.

10) Check your Work
To check your work, view the incoming signal, in realtime, at the bottom of the Probe dialog.



This display shows the sensor's value, in realtime, in native engineering units (e.g. Volts, Amps, degrees Celsius, strain) based on your software settings and external hardware wiring. The numerical value displayed at the bottom right is the actual real time value being read by instruNet. The plot shows the digitized version of your sensor value vs. time. The horizontal scale of this display is determined by the Pts Per Scan, No. of Scans, Scan Mode, Horiz Scale, and Sample Rate fields within the global Setup dialog (i.e. press the Record tab at the bottom of the instruNet World window, and then press the Setup button at the top). For details on how these work, please consult "Ch2, Working with the Voltage Inputs". To adjust the vertical scale of the probe display, select Display in the Setting popup, and then set the Disp Max EU and Disp Min EU fields to the desired engineering units values that correspond to the top and bottom of the display (e.g. set 1 and -1 to view a signal that varies from -1V to 1V). Press the Enter button to cause the new settings to take effect, and then view the updated display.

11) If your Sensor is not working, Fix it !

Listed below are several debugging hints for channels that are returning "bad" results:

a. Check that you have the correct channel

To check that you have the correct channel, and that it is being digitized by the software, view the probe dialog display as you disconnect one wire from your sensor. The value printed in the dialog lower right corner should change, to indicate that your displayed value is in some way connected to that wire. Also, if you touch the input terminal with your finger, you should notice some slight variation since your body acts as an antenna and causes radio stations, and such, to drive the input terminal (due to its high input impedance).

b. Check that instruNet is correctly measuring the voltage

At any time, you can set the Sensor popup to Volts, and set the Wiring popup to Vin+ - Vin- to cause instruNet to measure the voltage between the Vin+ and Vin- terminals. The measured voltage appears in the Probe dialog lower right. You can then check this against a volt meter that is placed in parallel between the Vin+ and Vin- terminals. Remember to set the Range popup if your signal is "clipping" on a bound. To measure the voltage between your Vin screw terminal (Vin+ or Vin-) and ground, you would do the same thing, yet select Vin - Gnd in the Wiring popup.

c. Check the engineering units calculations

If your voltage looks good, yet the returned engineering units value looks bad, then pull out a calculator (or better yet, a spreadsheet) and run your constants and known values into the equations listed in the Sensor Reference to check the processing of these numbers. Perhaps one of the fields in the Constants settings area is not set correctly.

d. Make sure you do not exceed the maximum input voltage

Make sure you are not exceeding the maximum input voltage, with respect to the Gnd terminal, as specified in "Ch8 Hardware Reference". To check this, measure the voltage between the Vin+ (or Vin-) terminal and the Gnd terminal with a Volt Meter. For example, in the Model 100, this voltage must not be less than -5V or greater than +5V. Exceeding a maximum typically does not cause damage unless it is very large (e.g. greater than +/- 20V).

e. Check your ground connections

If the ground between the instruNet device and your signal source is unstable, then connecting a wire between the instruNet Gnd terminal, and your signal source ground might help (e.g. attach a wire, or 1Kohm resistor, between the GND and Vin(-) terminals). Alternatively, if the instruNet Gnd is tied to the ground of your signal source, and these are at different voltages with respect to Earth ground, then current will flow between them. This current will cause voltage drops and subsequently may induce weird effects -- breaking this ground connection might help. The best way to determine what helps is to try different things (e.g. hold a wire between two grounds) and observe what happens in the display at the bottom of the Probe dialog.

g. Recheck your work

Recheck your hardware wiring and software settings.

12) Save your work.
To save the current configuration of instruNet (i.e. the settings displayed in the Network page and accessed via the Probe dialog), press the Network tab at the bottom of the window to select the Network page, and then press the Save button at the top of the window to save the settings to disk. A file save dialog appears, and it is here that you must specify a file name and file location (remember where you put it).

To check your saved settings: exit instruNet world, re-enter instruNet (e.g. launch Windows 95 "`instruNet World Win32.exe`" or Macintosh "`instruNet World Mac`"), press the Network tab at the bottom of the window to select the Network page, press the Open button at the top of the window, select your saved settings file (this will load your save settings), click on the channel that you just set up, and then view the realtime display at the bottom of the Probe dialog.

Alternatively, one could press the Store button to save the settings directly to a preferences file in the operating system folder, and then press the Restore button, at a later date, to restore them. The advantage of Save/Restore is the user does not need to specify a file name or file location; whereas the disadvantage is the saved file is overwritten the next time someone presses Store.

Sensor Reference

instruNet connects directly to a variety of sensors and returns engineering units, as summarized in the following pages. Each sensor must be wired exactly as shown in the following figures, and the software must be configured exactly as described in the adjacent instructions.

Single-ended Voltage Measurement

Single-Ended Voltage measurement involves reading a voltage between the Vin+ (or Vin-) instruNet input terminal and the Gnd input terminal, as illustrated in the figure to the right. The Gnd terminal is typically tied to earth ground through the user's cable, the instruNet network cable, or an external power supply cable. Most amplifiers that supply a single-ended output signal have their grounds tied to earth ground via the power supply cable. instruNet channels, configured for "Voltage" measurement, return a value in units of Volts. The Vin+ and the Vin- screw terminals function identically when used to read single-ended voltages (e.g. Ch1 corresponds to Vin+, and Ch2 corresponds to Vin- on the Model 100).

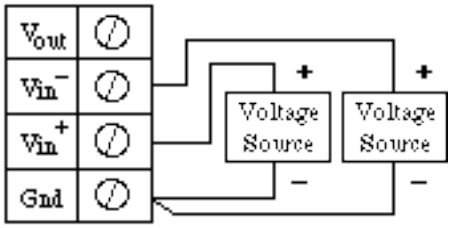


Fig 3.1 - Singled-Ended Voltage Measurement Mode with Two Signal Sources.

To do a Single-Ended Voltage measurement you must:

1. Set the Sensor field in the Hardware settings area to Voltage.
2. Set the Wiring field in the Hardware settings area to Vin - GND.
3. Wire your voltage source per figure 3.1, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.

Differential Voltage Measurement

Differential Voltage measurement involves reading a voltage between a pair of instruNet Vin+ and Vin- input terminals, as illustrated in the figure to the right. The Gnd terminal is not used when connecting a differential voltage source to instruNet; however, you must be careful to insure that the voltage applied to the Vin+ or Vin- terminal does not exceed the maximums specified in "Ch8 Hardware Reference" (e.g. all Vin terminals on the Model 100 must be kept between -5V and +5V, with respect to the Gnd terminal, in order to assure accurate readings). Differential mode is preferable for applications involving significant amounts of low frequency (< 5kHz) common mode noise that might result from long signal cables. instruNet channels, configured for "Voltage" measurement, return a value in units of Volts.

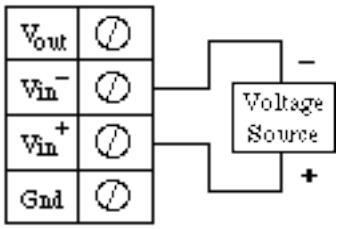


Fig 3.2 - Differential Voltage Measurement with One Signal Source.

To do a Differential Voltage measurement you must:

1. Set the Sensor field in the Hardware settings area to Voltage.
2. Set the Wiring field in the Hardware settings area to Vin+ - Vin-.
3. Wire your voltage source per figure 3.2, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.
4. If your measured signal is noisy, try connecting a wire (or 1Kohm resistor) between the Vin- and GND terminals (to reduce common mode noise), and refer to footnote #5 at the end of this chapter for details on how to low pass filter the measured signal.

Bridge Ratio Voltage Measurement

Bridge Ratio Voltage measurement involves measuring the ratio of the voltage measured across a bridge to the excitation voltage applied to the bridge, as illustrated in the figure to the right. This involves applying a voltage across the bridge and measuring the voltage across the two intermediate bridge nodes via a pair of instruNet Vin+ and Vin- input terminals. The excitation voltage for the bridge is supplied by either the instruNet Vout terminal or by an external voltage source. instruNet calculates the ratio, returning "V/V" engineering units, using the equations:

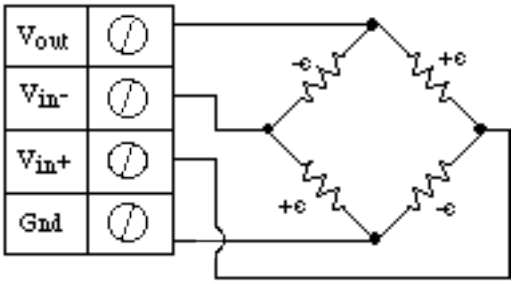


Fig 3.2b- Bridge Ratio Voltage Measurement

V_r (V/V) = ((V_{in}+ - Vin-) - Vinit) / V_{out}

Vinit and Vout are fixed values that are specified by the user in the Constants Settings area, whereas (Vin+ - Vin-) are measured in realtime by instruNet.

To do Voltage ratio measurement using a Bridge circuit you must:

1. Set the Sensor field in the Hardware settings area to Voltage.

2. Set the Wiring field in the Hardware settings area to Bridge .
3. Set the Ro field in the Constants settings area to the value of one Ro bridge resistor, in ohms units.[1,3]
4. Set the Vout field in the Constants settings area to specify an excitation voltage to be applied to the bridge. If you are applying an external excitation voltage, enter -Ro value in the Ro edit field (e.g. -100 instead of 100ohms) to tell the software that the excitation is external, and then enter the external excitation voltage in the Vout.[2] In high current cases (e.g. >2mA), it is often helpful to alternate the polarity of the excitation voltages to evenly burden the +/-12V supplies.[11]
5. Set the Vinit field in the Constants settings area to the voltage measured when the bridge is not stimulated, in Volts units (to null the bridge).[8]
6. Wire your voltage source per figure 3.2b, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.[5,10]

Current Measurement

Current measurement involves reading the voltage across an external user supplied shunt resistor, to which a current source is connected, as illustrated to the right. The voltage is measured between a pair of instruNet Vin+ and Vin- input terminals. instruNet then calculates the current through the shunt resistor using the following equation, and returns a value in "Amps" units:

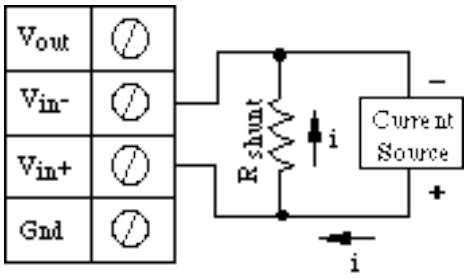


Fig 3.3 - Current Measurement.

current (Amps) = $(V_{in+} - V_{in-}) / R_{shunt}$

Shunt resistor values are typically chosen to cause a large voltage (several volts maximum) to be measured by instruNet, without saturating the current source (i.e. exceeding its maximum output voltage), and without heating up the resistor significantly to cause its resistance to change. If the Rshunt value is low, then the voltage across it is low, and this decreases the signal to noise ratio of the measured signal. Also, Rshunt must be selected such that the voltage across it does not exceed the instruNet maximum input voltage (e.g. +/-5V with the Model 100). Due to these limitations, instruNet might not let you set some of the fields too high or too low.

To do a Current measurement you must:

1. Set the Sensor field in the Hardware settings area to Current.
2. Set the Wiring field in the Hardware settings area to Shunt Resistor .
3. Set the Rshunt field in the Constants settings area to the value of your external user supplied Rshunt resistor, in ohms units.[1,3]
4. Set the Voltage Range field in the Hardware settings area to something similar to the maximum expected current * Rshunt.
5. Wire your current source per figure 3.3, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.
6. If your measured signal is noisy refer to footnote #5 at the end of this chapter for details on how to low pass filter the measured signal; also, if your current source is fully isolated from GND, connecting a 1K ohm (or wire) between the Vin- and GND terminals might reduce common mode noise.

Resistance Measurement: Voltage Divider Circuit

Resistance measurement using a voltage divider involves connecting a resistor of unknown value in series with an external user supplied shunt resistor of known value, applying a voltage across the divider circuit, and measuring the voltage across Runknown, as illustrated to the right. The voltage across Runknown is measured between a pair of instruNet Vin+ and Vin- input terminals while the excitation voltage is supplied by the instruNet Vout terminal. instruNet then calculates the value of Runknown using the following equation, and returns a value in "ohms" units:

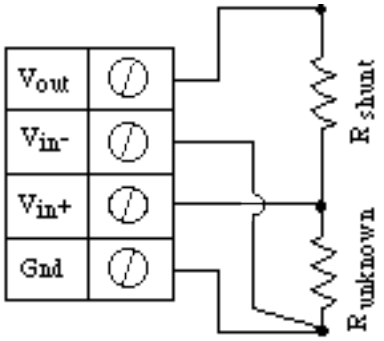


Fig 3.4 - Resistance Measurement - Voltage Divider Method

$R_{unknown}$ (Ohms) = R_{shunt} * (V_{in+} - V_{in-}) / ((V_{in+} - V_{in-}) - V_{out})

To do a Resistance measurement using a Voltage Divider, you must:

1. Set the Sensor field in the Hardware settings area to Resistance.
2. Set the Wiring field in the Hardware settings area to Voltage Divider .
3. Set the Rshunt field in the Constants settings area to the value of your external user supplied Rshunt resistor, in ohms units.[1,3,6]
4. Set the Vout field in the Constants settings area to specify the excitation voltage that is to be applied to the divider. In high current cases (e.g. >2mA), it is often helpful to alternate the polarity of the excitation voltages to evenly burden the +/- 12V supplies.[11]
5. Set the Voltage Range field in the Hardware settings area to something similar to Vout * (Runknown_Maximum / (Runknown_Maximum + Rshunt)).
6. Wire your voltage source per figure 3.4, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.[10]

Resistance Measurement: Bridge Circuit

Resistance measurement using a bridge circuit involves connecting a resistor of unknown value as one leg of a full-bridge circuit, applying a voltage across the bridge, and measuring the voltage across the two intermediate nodes. The intermediate node voltage is measured between a pair of instruNet Vin+ and Vin- input terminals while the bridge excitation voltage is supplied by either the instruNet Vout terminal or an external voltage source. In figure 3.5, Runknown is a resistor whose value is being measured and Ro is a similar valued resistor of known value[4]. This technique is only accurate if Runknown stays in the range of Ro, +/- 50%. If you need to measure a resistance with more range, please use the Resistance Measurement using a Voltage Divider, described earlier. instruNet calculates the value of Runknown using the following equation, and returns a value in "ohms" units:

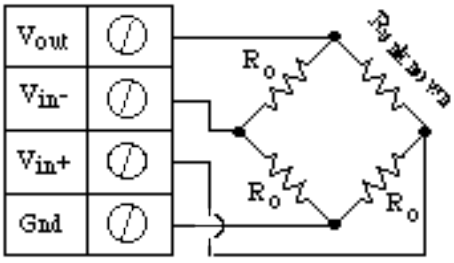


Fig 3.5 - Resistance Measurement - Bridge Circuit

Runknown (ohms) = R_O * (V_{out} - 2.0 * (V_{in+} - V_{in-})) / (V_{out} + 2.0*(V_{in+} - V_{in-}))

To do a Resistance measurement using a Bridge circuit you must:

1. Set the Sensor field in the Hardware settings area to Resistance.
2. Set the Wiring field in the Hardware settings area to Bridge .
3. Set the Ro field in the Constants settings area to the value of one Ro bridge completion resistor, in ohms units.[1,3,4]
4. Set the Vout field in the Constants settings area to specify an excitation voltage to be applied to the bridge. If you are applying an external excitation voltage, enter -Ro value in the Ro edit field (e.g. -100 instead of 100ohms) to tell the software that the excitation is external, and then enter the external excitation voltage in the Vout. In high current cases (e.g. >2mA), it is often helpful to alternate the polarity of the excitation voltages to evenly burden the +/-12V supplies.[11]
5. Wire your voltage source per figure 3.5, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.[5,10]

Strain Gage Measurement: Voltage Divider Circuit

Strain measurement using a voltage divider circuit involves connecting a strain gage in series with a shunt resistor of known value, applying a voltage across the pair and measuring the voltage across the strain gage, as illustrated to the right. The voltage across the strain gage is measured between a pair of instruNet Vin+ and Vin- input terminals while the excitation voltage for the divider is supplied by the instruNet Vout terminal. instruNet calculates the value of the strain using the following equations, and returns "strain" engineering units.

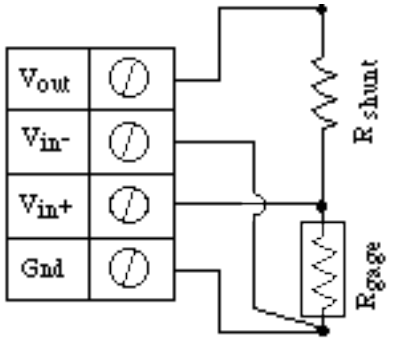


Fig 3.6- Strain Gage Measurement - Voltage Divider Circuit

R_{gage} (Ohms) = R_{shunt} * (Vin+ - Vin-) / (V_{out} - (Vin+ - Vin-))

Strain = ((1 / (GF * Ro)) * (R_{gage} - Ro))

Ro is the resistance of the unstrained strain gage and Rgage is the resistance of the gage when strained. Voltage divider circuits are less accurate than bridge circuits when measuring small resistance changes (which are typical in strain gage measurements), but are easier and less expensive to build. For strain gage measurements, a bridge circuit is highly recommended over a voltage divider.

To do a strain gage measurement using a Voltage Divider, you must:

1. Set the Sensor field in the Hardware settings area to Strain Gage.
2. Set the Wiring field in the Hardware settings area to Voltage Divider .
3. Set the Voltage Range field in the Hardware settings area to something similar to Vout * (Ro / (Rshunt + Ro)).
4. Set the Rshunt field in the Constants settings area to the value of your external user supplied Rshunt resistor, in ohms units.[1,3,6]
5. Set the Ro field in the Constants settings area to the value of your gage when unstrained, in ohms units.
6. Set the GF field in the Constants settings area to the gage's gage factor.[9]

7. Set the Vout field in the Constants settings area to specify the excitation voltage that is to be applied to the divider .[6] In high current cases (e.g. >2mA), it is often helpful to alternate the polarity of the excitation voltages to evenly burden the +/-12V supplies.[11]
8. Wire your strain gage per figure 3.6, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor .[5,10]

Strain Gage Measurement - Quarter Bridge

Strain measurement using a 1/4 bridge circuit involves wiring a strain gage as one leg of a full-bridge circuit, applying a voltage across the bridge, and measuring the voltage across the two intermediate bridge nodes via a pair of instruNet Vin+ and Vin- input terminals. The excitation voltage for the bridge is supplied by either the instruNet Vout terminal or by an external voltage source. In figure 3.7, R_{gage} is a strain gage, R_o is either a fixed resistor of known value or a fixed unstrained strain gage of value R_o, and R_L is the lead wire resistance. instruNet calculates the value of the strain, returning "strain" engineering units, using the equations:

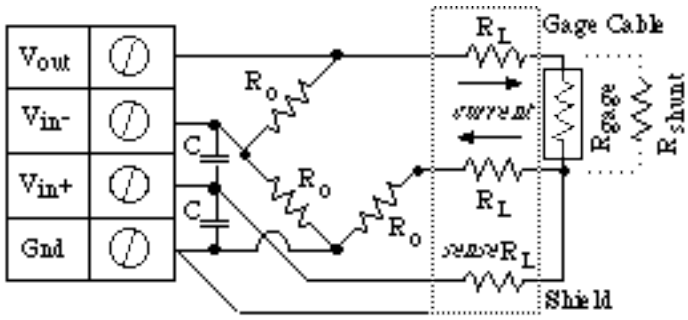


Fig 3.7 - Strain Measurement - Quarter Bridge Circuit

$$V_r\ (V/V) = ((V_{in}+ - Vin-) - Vinit) / V_{out}$$

$$Strain = (-4V_r / [GF * (1 + 2V_r)]) * (1 + R_L / R_o)$$

Ro, R_L, GF, Vinit and Vout are fixed values that are specified by the user in the Constants Settings area, whereas (V_{in}+ - Vin-) are measured in realtime by instruNet. R_o and Unstrained-R_{gage} must be the same value (e.g. 350ohms) in order for the bridge to operate properly.[4] For details on this measurement, please request the 6pg "Quarter Bridge Strain Gage" Application Note from your instruNet supplier.

To do Strain Gage measurement using a 1/4 Bridge circuit you must:

1. Set the Sensor field in the Hardware settings area to Strain Gage.
2. Set the Range field in the Hardware settings area to +/- 10mV.[7]
3. Set the Ro field in the Constants settings area to the value of one Ro bridge completion resistor, in ohms units .[3,4]
4. Set the GF field in the Constants settings area to the gage's gage factor.[9]
5. Set the Vout field in the Constants settings area to specify the voltage that is to be applied to the bridge (1V is typical). If you are applying an external excitation voltage, enter -Ro value in the Ro edit field (e.g. -100 instead of 100 ohms) to tell the software that the excitation is external, and then enter the value of the external excitation voltage into the Vout field (e.g. 4V).[2] In high current cases (e.g. >2mA), it is often helpful to alternate the polarity of the excitation voltages to evenly burden the +/-12V supplies.[11]

6. Set the delta, Rlead field in the Constants settings area to the resistance, in ohms, of the wires leading to the bridge (0 ohms is typically ok).
7. Set the Vinit field in the Constants settings area to the voltage measured when the bridge is unstrained, in Volts units.[8]
8. Set the Wiring field in the Hardware settings area to Q Bridge .
9. Capacitors across the voltage input terminals are highly recommended for reducing errors caused by RFI. With 350ohm gages, 0.1uF caps create a low pass filter at 4KHz [4K = 1 / (6.28 * 350 * .1e-6)], and are ideal at minizing RFI effects.
10. Wire your voltage source per figure 3.7, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.[5,10]

Strain Gage Measurement - Half Bridge (Bending)

Measuring bending strain using a 1/2 bridge configuration involves wiring two strain gages as shown in figure 3.8, applying a voltage across the bridge, and measuring the voltage across the two intermediate bridge nodes via a pair of instruNet Vin+ and Vin- input terminals. The excitation voltage for the bridge is supplied by either the instruNet Vout terminal or by an external voltage source. In figure 3.8, R_{gage} is a strain gage, R_o is either a fixed resistor of known value or a fixed unstrained strain gage of value R_o, and R_L is the lead wire resistance. instruNet calculates the value of the strain, returning "strain" engineering units, using the equations:

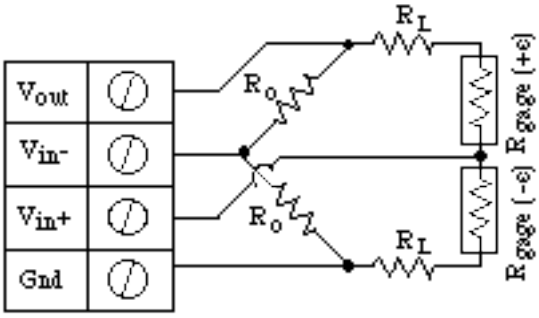


Fig 3.8 - Strain Measurement - Half Bridge Circuit

V_r (V/V) = ((V_{in}+ - Vin-) - Vinit) / V_{out}

Strain = (-2V_r / GF) * (1 + R_L /R_o)

Ro, R_L, GF, Vinit and Vout are fixed values that are specified by the user in the Constants Settings area, whereas (V_{in}+ - Vin-) are measured in realtime by instruNet. R_o and Unstrained-R_{gage} must be the same value (e.g. 350ohms) in order for the bridge to operate properly[4].

To do a bending Strain Gage measurement using a 1/2 Bridge circuit you must:

1. Do steps #1 through #7 listed in the previous "Strain Gage Measurement - Quarter Bridge" discussion.
2. Set the Wiring field in the Hardware settings area to H Bridge Bend .
3. Wire your voltage source per figure 3.8, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.[5,10]

Strain Gage Measurement - Half Bridge (Axial)

Measuring axial strain using a 1/2 bridge configuration involves wiring two strain gages as shown in figure 3.9, applying a voltage across the bridge, and measuring the voltage across the two intermediate bridge nodes via a pair of instruNet Vin+ and Vin- input terminals. The excitation voltage for the bridge is supplied by either the instruNet Vout terminal or by an external voltage source. In figure 3.9, R_{gage} is a strain gage, R_O is either a fixed resistor of known value or a fixed unstrained strain gage of value R_O, and R_L is the lead wire resistance. instruNet calculates the value of the strain, returning "strain" engineering units, using the equations:

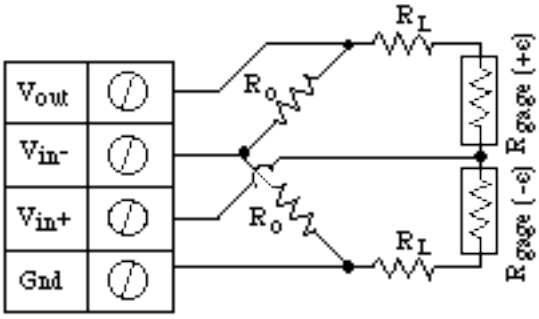


Fig 3.9 - Strain Measurement - Half Bridge Circuit (Axial)

$$V_r\ (V/V) = ((V_{in}+ - Vin-) - Vinit) / V_{out}$$

$$Strain = (-4V_r / [GF * [(1 + \upsilon) - 2V_r (\upsilon - 1)]]) * (1 + R_L / R_O)$$

υ, Ro, R_L, GF, Vinit and Vout are fixed values that are specified by the user in the Constants Settings area, whereas (V_{in}+ - Vin-) are measured in realtime by instruNet. R_O and Unstrained-R_{gage} must be the same value (e.g. 350ohms) in order for the bridge to operate properly[4].

To do axial Strain Gage measurement using a 1/2 Bridge circuit you must:

1. Do steps #1 through #7 listed in the previous "Strain Gage Measurement - Quarter Bridge" discussion.
2. Set the Wiring field in the Hardware settings area to H Bridge Axial .
3. Set the v_Poisson field in the Constants settings area to the υ poissson value of the material that your are twisting (e.g. aluminum is .32).
4. Wire your voltage source per figure 3.9, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.[5,10]

Strain Gage Measurement - Full Bridge (Bending)

Measuring bending strain using a full bridge configuration involves wiring four strain gages as shown in figure 3.10, applying a voltage across the bridge, and measuring the voltage across the two intermediate bridge nodes via a pair of instruNet Vin+ and Vin- input terminals. The excitation voltage for the bridge is supplied by either the instruNet Vout terminal or by an external voltage source. instruNet calculates the value of the strain, returning "strain" engineering units,

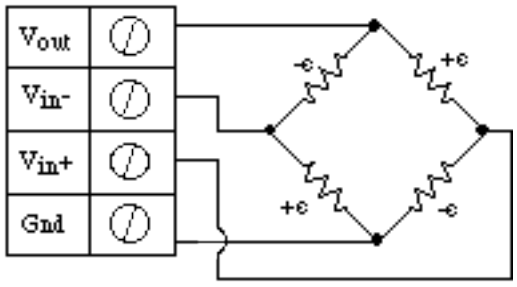


Fig 3.10 - Strain Measurement - Full Bridge Circuit (Bending)

using the equations:

V_r (V/V) = ((V_{in}+ - Vin-) - Vinit) / V_{out}

Strain = -V_r / GF

GF, Vinit and Vout are fixed values that are specified by the user in the Constants Settings area, whereas (Vin+ - Vin-) are measured in realtime by instruNet.

To do bending Strain Gage measurement using a Full Bridge circuit you must:

1. Do steps #1 through #7 listed in the previous "Strain Gage Measurement - Quarter Bridge" discussion.
2. Set the Wiring field in the Hardware settings area to F Bridge Bend.
3. Wire your voltage source per figure 3.10, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.[5,10]

Strain Gage Measurement - Full Bridge (Axial I)

Measuring axial strain using a full bridge configuration involves wiring four strain gages as shown in either figure 3.11 or figure 3.12, applying a voltage across the bridge, and measuring the voltage across the two intermediate bridge nodes via a pair of instruNet Vin+ and Vin- input terminals. The excitation voltage for the bridge is supplied by either the instruNet Vout terminal or by an external voltage source. instruNet calculates the value of the strain, returning "strain" engineering units, using the equations:

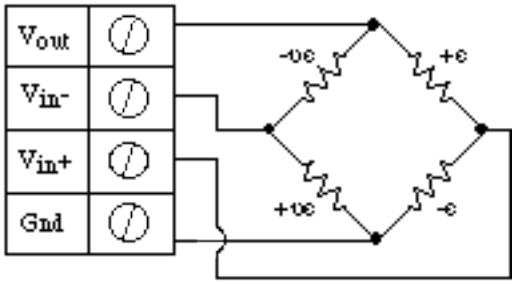


Fig 3.11 - Strain Measurement - Full Bridge Circuit (Axial I)

V_r (V/V) = ((V_{in}+ - Vin-) - Vinit) / V_{out}

Strain = -2V_r / GF (υ + 1)

υ, GF, Vinit and Vout are fixed values that are specified by the user in the Constants Settings area, whereas (Vin+ - Vin-) are measured in realtime by instruNet.

To do Axial Strain Gage measurement using a Full Bridge circuit you must:

1. Do steps #1 through #7 listed in the previous "Strain Gage Measurement - Quarter Bridge" discussion.
2. Set the Wiring field in the Hardware settings area to F Bridge Axl I.
3. Set the v_Poisson field in the Constants settings area to the υ poison value of the material that your are twisting (e.g. aluminum is .32).
4. Wire your voltage source per figure 3.11, and refer to the steps at the beginning of this chapter for more information on how to set up your

Strain Gage Measurement - Full Bridge (Axial II)

Measuring axial strain using a full bridge configuration involves wiring four strain gages as shown in figure 3.12, applying a voltage across the bridge, and measuring the voltage across the two intermediate bridge nodes via a pair of instruNet Vin+ and Vin- input terminals. The excitation voltage for the bridge is supplied by either the instruNet Vout terminal or by an external voltage source. instruNet calculates the value of the strain,
returning "strain" engineering units, using the equations:

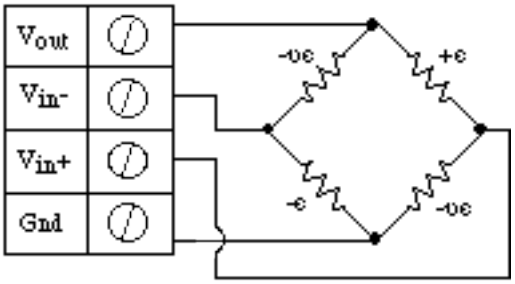


Fig 3.12 - Strain Measurement - Full Bridge Circuit (Axial II)

V_r (V/V) = ((V_{in}+ - Vin-) - Vinit) / V_{out}

Strain = $-2V_r / [GF [(\upsilon + 1) - V_r (\upsilon - 1)]]$

υ, GF, Vinit and Vout are fixed values that are specified by the user in the Constants Settings area, whereas (Vin+ - Vin-) are measured in realtime by instruNet.

To do Axial Strain Gage measurement using a Bridge circuit you must:

1. Do steps #1 through #6 listed in the previous "Strain Gage Measurement - Quarter Bridge" discussion.
2. Set the Wiring field in the Hardware settings area to F Bridge II .
3. Set the v_Poisson field in the Constants settings area to the υ poisson value of the material that your are twisting (e.g. aluminum is .32).
4. Wire your voltage source per figure 3.12, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.[5,10]

Temperature Measurement (RTD) Voltage Divider[1]

Temperature measurement using a voltage divider circuit involves connecting an RTD in series with a shunt resistor of known value, applying a voltage across the pair and measuring the voltage across the RTD, as illustrated to the right. The voltage across the RTD is measured between a pair of instruNet Vin+ and Vin- input terminals while the excitation voltage for the divider is supplied by the instruNet Vout terminal. instruNet calculates the value of the strain using the following equations, and returns "degrees C" engineering units.

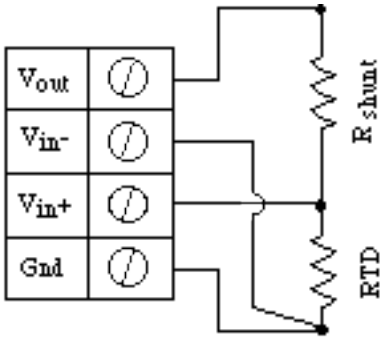


Fig 3.13 - Temperature Measurement (RTD) Voltage Divider Circuit

R_{RTD} (Ohms) = R_{shunt} * (Vin+ - Vin-) / (V_{out} - (Vin+ - Vin-))
a = Ro * alpha (1.0 + (delta / 100.0))
b = Ro * -1.0 * alpha * delta / (100.0 * 100.0)
c = Ro - R_{RTD}
Temperature (Celsius) = c / (-0.5 * (b + sqrt((b*b) - (4.0 * a * c))))

Alpha is the temperature coefficient of the RTD at 0C (typically .00385 for American RTD's, and .00392 for European RTD's) and delta is the Callendar-Van Dusen delta constant (typically 1.492). These constants are often supplied by the manufacturer of the RTD. The instruNet temperature linearizer only supports temperatures above 0°C.

Many RTD manufacturers recommend a 1mA RTD current source with RTD voltage dividers since this often dissipates several milliwatts, and therefore does not cause noticeable "self" heating. An example would be a 100 ohm RTD (which will vary from 25 to 400 ohms as the temperature varies; i.e. 25% to 400%), a 4.5V excitation voltage (i.e. Vout) and a 5000 ohm shunt resistor. The average current and power dissipation of the RTD at 0°C would be:

Current (Amps) = Volts / Resistance = 4.5V / [5000 + 100] = .88mA

Power (watts) = Current * Current * Resistance = .0088 * .0088 * 5100 = 3.8mW

The voltage across the RTD would vary from 22mV to 352mV as the resistance across the RTD changed from 25 to 400 ohms (corresponding to a temperature change of -260 to +850 Celsius); therefore, an input Voltage Range of ±600mV would be ideal with a 100 ohm RTD, 4.5V Vout voltage, and 5000 ohm resistor.

To do temperature measurement using an RTD in a voltage divider circuit you must:

1. Set the Sensor field in the Hardware settings area to RTD.
2. Set the Wiring field in the Hardware settings area to Voltage Divider .
3. Set the Voltage Range field in the Hardware settings area to something similar to Vout * (RTD_Max / (Rshunt + RTD_Max)), where RTD_Max is the RTD resistance at 0°C times 4.
4. Set the Rshunt field in the Constants settings area to R_{shunt}.[1,3,6]
5. Set the Ro field in the Constants settings area to the resistance of the RTD at 0°C, in ohms units.
6. Set the Vout field in the Constants settings area to specify the excitation voltage that is to be applied to the divider. In high current cases (e.g. >2mA), it is often helpful to alternate the polarity of the excitation voltages to evenly burden the +/- 12V supplies.[11]
7. Set the alpha field in the Constants settings area to the alpha value of your RTD.
8. Set the delta,Rlead field in the Constants settings area to the delta value of your RTD.
9. Wire your voltage source per figure 3.13, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor. To reduce noise, 0.001 seconds of integration is often helpful (i.e. set the Integrate field in the Hardware setting area to 0.001). [5, 10]

Temperature Measurement (RTD) Bridge Circuit

Temperature measurement using an RTD in a bridge circuit involves wiring an RTD as one leg of a full-bridge circuit, applying a voltage across the bridge, and measuring the voltage across the two intermediate bridge nodes via a pair of instruNet Vin+ and Vin- input terminals. The excitation voltage for the bridge is supplied by either the instruNet Vout terminal or by an external voltage source. In figure 3.14 R_{RTD} is an RTD and R_O is a resistor of known, similar, value. instruNet calculates the value of the temperature, returning degrees Celsius engineering units, using the equations:

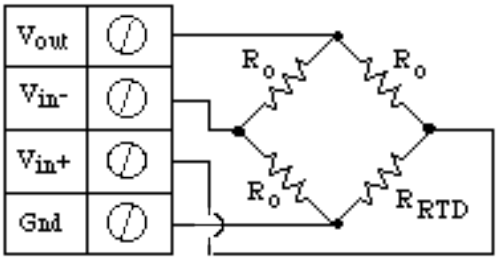


Fig 3.14 - Temperature Measurement (RTD) Bridge Circuit

R_{RTD} (Ohms) = (Ro * (Vout - 2.0 * (Vin+ - Vin-)) / (Vout + 2.0 * (Vin+ - Vin-))
a = Ro * alpha (1.0 + (delta / 100.0))
b = Ro * -1.0 * alpha * delta / (100.0 * 100.0)
c = Ro - R_{RTD}
Temperature (Celsius) = c / (-0.5 * (b + sqrt((b*b) - (4.0 * a * c))))

Alpha is the temperature coefficient of the RTD at 0C (typically .00385 for American RTD's, and .00392 for European RTD's) and delta is the Callendar-Van Dusen delta constant (typically 1.492). These constants are supplied by the manufacturer of the RTD. The instruNet temperature linearizer only supports temperatures above 0°C.

The RTD bridge circuit is very accurate when the RTD resistance is close to the Ro bridge resistance. (i.e. the RTD resistance varies between .5 * Ro and 2 * Ro). If you need more RTD temperature range, please use the RTD Voltage Divider circuit.

To do temperature measurement using an RTD in a bridge circuit you must:

1. Set the Sensor field in the Hardware settings area to RTD.
2. Set the Wiring field in the Hardware settings area to Bridge.
3. Set the Range field in the Hardware settings area to something small such as +/- 100mV.
4. Set the Ro field in the Constants settings area to the resistance of the RTD at 0°C, in ohms (typically, this is also be the bridge completion resistor resistance).[3,4]
5. Set the alpha field in the Constants settings area to the alpha value of your RTD.
6. Set the delta,Rlead field in the Constants settings area to the delta value of your RTD.
7. Set the Vout field in the Constants settings area to specify the voltage that is to be applied to the bridge (1V is typical). If you are applying an external excitation voltage, enter -Ro value in the Ro edit field (e.g. -100 instead of 100 ohms) to tell the software that the excitation is external, and then enter the value of the external excitation voltage into the Vout field (e.g. 4V).[2] In high current cases (e.g. >2mA), it is often helpful to alternate the polarity of the excitation voltages to evenly burden the +/-12V supplies.[11]
8. Wire your voltage source per figure 3.14, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor. To reduce noise, 0.001 seconds of integration is often helpful (i.e. set the Integrate field in the Hardware setting area to 0.001).[5,10]

Temperature Measurement Thermocouple

Temperature measurement using a thermocouple involves connecting the two thermocouple leads to a pair of instruNet Vin+ and Vin- input terminals. If this voltage floats with respect to the instruNet Gnd terminal, it might be necessary to also attach the instruNet Vin- terminal to the instruNet Gnd terminal with a short wire. Sometimes this wire makes things better, and sometimes this wire makes things worse. instruNet calculates the value of the temperature in degrees Celsius using a polynomial linearizing equation.

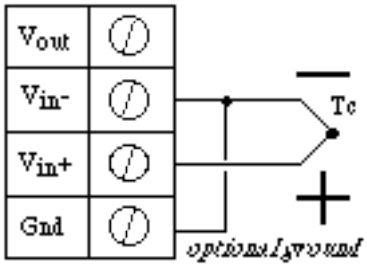


Fig 3.15 - Temperature Measurement (Thermocouple)

To do temperature measurement using a thermocouple you must:

1. Set the Sensor field in the Hardware settings area to the appropriate Thermocouple type (J, K, T, E, R, S).
2. Set the Wiring field in the Hardware settings area to Vin+ - Vin-.
3. Set the Range field in the Hardware settings to either +/- 80mV or +/- 10mV (approximately) depending on the temperature range being measured. If your temperature range is <170C for a type J thermocouple, <230C for a type K thermocouple, <180C for at type T thermocouple, <900C for a type R thermocouple, <900C for a type S thermocouple or between -250C to 140C for type E thermocouple, then set the range to approximately +/- 10mV. Otherwise set the Range for approximately +/- 80mV. Measurement resolution is approximately 1.2µV in the +/- 10mV range and approximately 10µV in the +/- 80mV range.
4. Wire your voltage source per figure 3.15, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor.[5,10] If your thermocouple leads are backwards, then the measured temperature will be shown as varying in the opposite direction from ambient (e.g. if the instruNet terminals are at 25°C, the thermocouple is at 35°C, and the leads are backwards, then instruNet will report 15°C.).
5. If your measured signal is noisy, try connecting a wire (or 1Kohm resistor) between the Vin- and GND terminals (to reduce common mode noise), and refer to footnote #5 at the end of this chapter for details on how to low pass filter the measured signal. To reduce noise, 0.001 seconds of integration is often helpful (i.e. set the Integrate field in the Hardware setting area to 0.001).

Thermistor Temperature Measurement

Thermistors are two wire devices whose resistance varies with temperature in a known fashion, often accurate to +/- 0.2°C. The instruNet thermistor measurement feature supports ysi-Omega 100ohm to 1Mohm thermistors between the temperatures of -80°C to 250°C. When Thermistor is selected in the Sensor popup, instruNet assumes a thermistor is connected in the prescribed fashion, and subsequently returns the thermistor temperature in degrees C units after applying a Steinhart & Hart resistance-to-temperature conversion. Measuring a thermistor temperature involves a voltage divider circuit with a shunt resistor of known value, applying a voltage across the pair and measuring the voltage across the thermistor, as illustrated to the right. The voltage across the thermistor is measured between a pair of instruNet Vin+ and Vin- input terminals while the excitation voltage for the divider is supplied by the instruNet Vout terminal. instruNet calculates the thermistor resistance using the following equation.

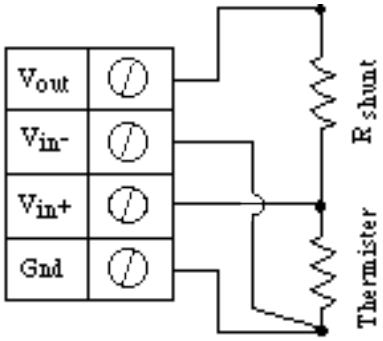


Fig 3.16 - Temperature Measurement (Thermistor) Voltage Divider Circuit

R_{Therm} (Ohms) = R_{shunt} * (Vin+ - Vin-) / (V_{out} - (Vin+ - Vin-))

$Temperature_{Therm}$ (°C) = -273.15 + 1.0 / (a + b (Ln(R_{Therm})+c (Ln(R_{Therm}))^3)

a, b, and c are a function of 3 points in the resistance-to-temperature table, as are calculated by instruNet after the user completes a short dialog box interview. To minimize "self heating", it is recommended that thermistors operate at less than 100uW (50uW is better). An example would be a 2252 ohm thermistor (which will vary from 394.5 to 7355 ohms in the 0-70°C temperature range). With .37V excitation voltage (i.e. Vout) and a 1000 ohm shunt resistor, the current and power dissipation at 70°C would be 100uW:

Current (Amps) = Volts / Resistance = 0.37V / [1000 + 394.5] = .265mA

Power (watts) = Current ^{2} * Resistance = .000265^2 * 1394.5 = 100uW

The voltage across the thermistor would vary from 104mV to 320mV as the resistance across the thermistor varied from 394 to 7355 ohms; therefore, an input Voltage Range of ±.6V would work nicely in this case. Shunt resistors with an initial accuracy of .025%, and a temperature drift of 20ppm/°C, such as the Caddock part #TN130-resistance-0.025%-20, are recommended[1,3,6].

To do temperature measurement using a Thermistor, the user must:

1. Set the Sensor field in the Hardware settings area to Thermistor. This will cause a series of dialog boxes to appear, asking the user several questions about the thermistor type (i.e. resistance at 25°C), shunt resistor value, and excitation voltage. It also recommends an excitation voltage and shunt resistor value based on the thermistor in use, and the temperature range of interest -- in many cases, using the recommended values are the best options. Based on the responses to these questions, instruNet loads the following fields in the Constants setting group, with the following information:

Ro thermistor resistance at 25°C, in units of ohms

Rshunt	actual shunt resistance, in units of ohms
Vout	excitation voltage output the Vout screw terminal
alpha	the 'a' Steinhart & Hart coefficient
delta,Rlead	the 'b' Steinhart & Hart coefficient
GF	the 'c' Steinhart & Hart coefficient
V_poisson	the maximum expected temperature, in degrees C units
Vinit	the minimum expected temperature, in degrees C units

instruNet also sets the Voltage Range field in the Hardware settings area to a value appropriate to the specified temperature range. The smaller the temperature range, the better the accuracy; therefore one should not make the specified range unnecessarily large.

If you want to run through the dialog box interview again, select Voltage in the Sensor field, and then select Thermistor, to invoke the interview again.

If you want to manually set any of the fields in the Constants settings group, do the interview, and then set them to your liking, after selecting Constants in the Settings popup.

2. Wire your thermistor per figure 3.16, and refer to the steps at the beginning of this chapter for more information on how to set up your sensor. To reduce noise, 0.001 seconds of integration is often helpful (i.e. set the Integrate field in the Hardware setting area to 0.001) [5, 10].

Sensor Reference Footnotes

1 Heating Considerations with Resistors

When current is pumped through a resistor, it heats up. When a resistor heats up, its resistance changes, and this can cause errors in your measurement. The current though a resistor is calculated via:

```
Current (Amps) = Volts Across Resistor / Resistance in ohms
```

The power dissipated by a resistor is:

```
Power Dissipated (Watts)  = Volts * Volts / Resistance
                          = Current  * Current  * Resistance
```

The amount a resistor heats up is:

```
Change in Temperature (Celsius) = Thermal Resistance (C/Watt)
                                  * Power Dissipated (Watts)
```

The amount a resistor changes for a change in temperature is:

```
Change in Resistance (ohms) = Change in Temperature (Celsius)
                            * Temperature Coefficient (ppm/C)
                            * Resistor Value (ohms)
```

For example, a 100ohm resistor with a 100 ppm/C temperature coefficient and 30C/Watt thermal resistance that is passing 50milliAmps would enjoy the following situation:

```
5Volts across resistor = 100ohms * 50mA
0.25Watts power dissipation = 5V * 5V / 100ohms
7.5°C temperature change = 30C/Watt * .25Watts
0.075 ohms change due to temperature change = 7.5°C temp
```

```
change * .0001ohms/ohm/C thermal resistance * 100 ohms
```

2 Excitation Voltages for Bridge Circuits

If you type an unreasonably high value into the Vout field of the Constants area and press Enter, instruNet will set the output voltage to the highest possible value without allowing the internal output amplifier to saturate (e.g. ≤ 4mA for #iNet-100/100B and ≤15mA for #iNet-100HC). Setting the highest possible Vout, causes the highest possible voltage to be read by the Vin terminals, which increases the signal to noise ratio and therefore increases accuracy. The downside to having a high excitation voltage is that it increases the power dissipated by the resistors, which increases their thermal heating, which increases the drift from their resistance's at ambient temperature (e.g. typical resistors offer 100ppm resistance drift per degree C change in temperature). Resistors with low temperature coefficients (e.g. 25ppm/C) are helpful if this is a problem. Also, if noise is a problem, it is sometimes helpful to install a capacitor (e.g. 1µF) between the Vout terminal and GND, at the bridge (possibly far from instruNet), to hold the excitation voltage steady.

3 Shunt Resistors and Bridge Completion Resistors

Bridge completion resistors and shunt resistors should be as accurate as possible (.1% is often ok, .01% is very good), and have a low temperature coefficient (25ppm/C is often ok, 5ppm/C is very good). If you use a less accurate resistor, we recommend that you measure it with a DVM, and then type this more accurate value into the Rshunt field in the Constants setting area. To determine the effect of a resistor inaccuracy, calculate your engineering units for a typical case, and then increase the resistor value by its expected error, and note the change in the resulting engineering units output. For example, if a 100ohm shunt resistor is used to measure a 1mA current source and it changes 1%, then the measured reading would change 1%, or .01mA.

Several manufacturers of resistors are listed below:

a. Caddock Electronics Inc, USA telephone 1-541-496-0700, Ask for "Greg, The Resistor Man" or a "Resistor Applications Engineer", fax 1-541-496-0408. Caddock offers very precise resistors in the $2 to $20 range. The "MK132 -*Value* - *Tolerance*" series parts are 3/4W, 30-5Mohms, .1% to 5% initial accuracy, 50ppm/C; and the "TF020R - *Value* - *Tolerance* - *Temperature Coefficient*" series parts are .33W, 1K-2Mohms, .01% to 1%, 5 to 15ppm/C. They accept VISA and MasterCard, have no minimum order, and often have items in stock.

b. Digi-Key Corporation, USA telephone 1-800-344-4539, fax 1-218-681-3380. Part # "*value* X-ND" are $.50, 1/4Watt, 100ppm/C temperature drift, 1% initial accuracy Resistors that are not too accurate yet very easy to order and are low cost.

c. "RN 55 E *value* 0.1%" resistors are a common series that offers 1/8Watt, 0.1% initial accuracy, and 25ppm/C temperature drift for approximately $1. Also, the "RNC 60H *value* 0.1%" series is similar, yet with 50ppm/C temperature drift at 1/4W. These are manufactured by folks like IRC Inc, and Dale Inc; and distributed by companies like Newark Electronics (USA telephone 800-463-9275, fax 1-312-907-5217) and Allied Electronics (USA telephone 1-800-433-

5700, fax 1-817-595-6444). They accept common credit cards, and if one series is not in stock, ask them to suggest something that is similar.

4 Bridge Completion Resistors in Strain Gage Bridge Circuits

In a bridge, all 4 resistors must be the same value, within 10% or so (1% is better, .1% is excellent), in order for the bridge to operate properly. In some bridge circuits, all 4 resistors are supplied by the sensor manufacturer; whereas in others (e.g. 1/4 or 1/2 bridge circuits), the user must supply "completion" resistors of the same value as the gage to complete the bridge circuit. This can be done by installing precision resistors (e.g. 0.1%), or by installing fixed unstrained strain gages of the same ohmic value.[3]

5 Filter Settings for Low Level Measurements

Strain gage, thermocouple, and RTD voltages are typically very low and therefore often require low pass filtering to reduce noise. Low pass filters cause high frequencies to be rejected, while low frequencies are passed. Visually, the signal becomes "smoother". instruNet provides several low pass filter options:

a) The Low Pass popup menu in the Hardware settings area can select a variety of analog low pass filter options (e.g. the Model 100 provides the following analog one pole low pass options: off, 40Hz, and 4KHz).
b) The Integrate field in the Hardware Settings area selects how long the signal is averaged before instruNet returns one number. This "averaging", in effect, is a low pass filter. Careful, this averaging fully consumes the instruNet controller, and therefore reduces the maximum possible sample rate. A 0.001 sec integration time is often very helpful at reducing noise and increasing accuracy.
c) The Low Pass settings area provides a means by which one can digitally filter a signal, post acquisition, with tremendous accuracy.
d) The user can manually place a capacitor across the Vin+ and Vin- input terminals with any bridge or voltage divider circuit to provide a 1pole low pass filter where the cut-off Frequency in Hertz is equal to $1 / (2 * \pi * R * C)$; where R is the source resistance in ohms, C the parallel capacitance in Farads, and π is 3.14159.

6 Selecting a Voltage Divider Shunt Resistor

Shunt resistor values are typically chosen to cause a large voltage (several volts maximum) to be measured by instruNet, without heating up the resistor significantly to cause its resistance to change or causing the excitation voltage source to over shoot its maximum output current (e.g. 4mA on the #iNet-100/100B and 15mA on #iNet-100HC). If the Rshunt value is low, then the voltage across it is low, and this decreases the signal to noise ratio of the measured signal. Also, Rshunt must be selected such that the voltage across Runknown does not exceed the instruNet maximum input voltage (e.g. +/-5V with the Model 100). Due to these limitations, instruNet might not let you set some of the fields too high or too low.

7 Voltage Range Settings For Strain Gages

Since strain gage voltages are often very small, a small input range (e.g. +/- 10mV) works best for most measurements. Increasing the voltage range increases the range of strain that can be read, while sacrificing accuracy with small voltages (e.g. instruNet can read 5mV more accurately with a +/-10mV range, than with a +/-100mV range). Please refer to your equation for details on how strain relates to voltage measured.

8 Balancing your Bridge with the Vinit Correction Voltage

Vinit is the voltage measured across the intermediate nodes of the bridge when the strain gage(s) are unstrained in a bride circuit. This is measured by putting instruNet into Voltage mode, Differential Wiring, with a low voltage Range (e.g. +/-10mV), and then measuring the resulting bridge voltage (e.g. via the value shown at the bottom of the Probe dialog). You must then enter this voltage value into the Vinit field in the Constants settings area, reset your Sensor field to Strain Gage, and reset your Wiring field to where you had it. Subsequently, all reported "strain" values will reflect resistance changes from the "unstrained" scenario. Vinit is used as an offset correction factor to "balance" the bridge. If you do not want to go through the trouble of "balancing" your bridge, simple set Vinit to 0.

9 The Strain Gage "GF" Factor

All strain gages are manufactured with a specific Gage Factor (GF), which relates a change in resistance, to strain. The GF is often printed on the strain gage package, and must be correctly entered into the instruNet GF field within the Constants settings area. This is used to calculate the "strain" value returned by instruNet.

10 Accuracy of Measurements

Accuracy measurements are affected by the noise pickup on the leads, the accuracy of the sensor itself (i.e. thermocouple's are typically accurate to +/- 1C to 3C) and the instruNet measuring system. A noisy environment and long sensor leads are often the worst threat to accuracy. Integrating (via the Integrate field) a signal over a period of time will give a more accurate measurement by filtering out noise at the expense of a lower maximum sample rate.

An example of how to calculate accuracy is as follows:

Suppose you are doing a current measurement where the current is calculated as the voltage drop across a shunt resistor divided by the resistance in ohms of the resistor.

Current (Amps) = Volts across shunt resistor / shunt resistance in ohms

Suppose the measured voltage is accurate to 1mV and the 1K ohm shunt resistor is accurate to 1%. Subsequently, the accuracy of the measured current would be

Max Current Error = 1mV / (.01 * 1K) = 100microAmps

11 Alternating Positive and Negative Excitation Voltages

To reduce the burden on one side of a power supply (e.g. +12V or -12V), excitation voltages often alternate postive and negative. For example, when powering 350ohm strain gages, the excitation voltages are typically set to {+5V, -5V, +5V, -5V...}. The alternating polarity evenly burdens the +/-12V supplies. Please note that in low current cases (e.g. <2mA), this is not necessary.

4 A Tutorial For Programmers

This chapter explains how to control instruNet from a programming environment such as C or Visual Basic. It assumes you have done the tutorial in Chapter 2, in its entirety. If you haven't, please do so now. This chapter also assumes you have a working knowledge of your programming language and programming tools.

Programming Overview

An instruNet data acquisition system is controlled with one main subroutine, called iNet(), that is callable from C or Visual Basic. The actual iNet() code resides in the instruNet Driver file that you installed in Ch 1 (i.e. Macintosh Code Resource or a Windows 32bit DLL).

iNet() Function Call

The iNet() function includes 7 parameters that specify a field in the network hierarchy that is to be read or written to, as shown below:

```
iNetINT16 iNet(

   iNetUINT8 netNum,       NETWORK number = {0...numNetworks}, 0 is
                           Driver, 1 is 1st Controller installed
                           into the computer, 2 is the 2nd
                           Controller, etc.

   iNetUINT8 deviceNum,    DEVICE number {0...numDevices}, 0 =
                           "Controller", 1 = 1st device on net...

   iNetUINT8 moduleNum,    MODULE number within a hardware DEVICE
                           {1...32}. Each DEVICE can contain up to
                           32 separate modules.  Many devices have
                           only 1 module.

   iNetUINT8 chanNum,      Hardware CHANNEL number {1...32}. Each
                           device contains a number of channels
                           (i.e. signals that are accessed//via a
                           screw terminal or connector), each of
                           which has its own channel #.
```

```
   iNetINT16 fieldGroupNumOrType,
                              If > 0, this is a field Group Number
                              {1...numFieldGroups}.  if < 0, this is a
                              field Group Type.

   iNetINT16 fieldNum,        Field number within the fieldGroup of
                              the CHANNEL.

   iNetUINT8 intention        ion_intention = {intention_getValue,
                              intention_setValue,
                              intention_getNameStr,
                              intention_getMaxValue}

   iNetUINT8 argType          argument type {int16, int32, str15,
                              etc}(void *ptrToArg) this is where data
                              is kept (we read or write to this
                              location).
```

These parameters specify a field, such as the cut-off frequency of a low pass filter, the sample rate, or the actual real-time value of a channel. This function can both read from and write to any field on the network. For a description of each field, please refer to Ch 6. One uses iNet() to both set up the networks, and then do I/O with the various channels. Also, iNet() can be used to tell the instruNet Controllers to digitize, and then download the digitized data into computer memory. iNet() is extremely powerful -- it can even open the instruNet World window and turn over control to the user.

Simple Format Functions

There are also a collection of Simple Format functions that read and write instruNet fields using a structure that specifies a channel address {netNum, deviceNum, moduleNum, chanNum}. This structure ("User Defined Variable Type" if in Visual Basic) is defined as follows:

```
typedef struct iNetChannelAddr {

   iNetUINT8 netNum;          NETWORK number = {0...numNetworks}, 0 is
                              Driver, 1 is the first controller installed
                              into the computer.

   iNetUINT8 deviceNum;       DEVICE number = {0...numDevices},
                              0 = "Controller", 1 = 1st device on network.

   iNetUINT8 moduleNum;       MODULE number within hardware DEVICE {1-32}.
                              Many devices have only 1 module.

   iNetUINT8 chanNum;         Hardware CHANNEL number {1...32}. Each
                              device contains a number of channels,
                              each of has which its own channel number.
} iNetChannelAddr;
```

To read or write an instruNet field with a Simple Format function, one must first load an `iNetChannelAddr` structure with the netNum, deviceNum, moduleNum, chanNum. This is often done with the `LoadChannelAddress()` routine:

```
 LoadChannelAddress()      Specify an instruNet channel address.
```

After the structure is loaded (it holds the netNum, moduleNum, deviceNum, chanNum information), one can then read or write an instruNet field with any of the following routines:

```
SetField_int32()    Set instruNet field with 32bit signed
                    integer number.
SetField_uint32()   Set instruNet field with 32bit unsigned
                    integer number.
SetField_flt32()    Set instruNet field with 32bit floating
                    point number.
SetField_cStr()     Set instruNet field with C string
                    (terminated with 0x00).
GetField_int32()    Read instruNet field into a 32bit signed
                    integer variable.
GetField_uint32()   Read instruNet field into a 32bit unsigned
                    integer variable.
GetField_flt32()    Read instruNet field into a 32bit floating
                    point variable.
GetField_cStr()     Read instruNet field into a C string
                    variable (terminated with 0x00).
```

For example, the following C code would read the real-time value of Channel 1 at Device 1, Module 1, Network 1:

```
iNetChannelAddr vin;
iNetFLT32 V;
iNetError e;

LoadChannelAddress(&vin, 1, 1, 1, 1);

V = GetField_flt32(&vin,sgt_General,fldNum_General_valueEu,&e);
```

Digitizing

There are several routines, summarized below, that are used to simultaneously digitized channels to ram or to disk, as described in C file `INET_INT.C` and Visual Basic file `INET_Common_Code.bas`.

```
EnableChannelForDigitizing()
                    Mark this channel for digitizing (i.e. when
                    digitizing is started).
DisableAllChannelsForDigitizing()
                    Disable all channels for digitizing.
Set_iNet_TIMING_Parameters()
                    Set digitize timing parameters (e.g.
                    sampleRate, ptsPerScan, etc).
Set_iNet_TRIGGER_Parameters()
                    Set digitize trigger parameters (e.g.
                    trigger on/off, trigger source).
Service_All_iNet_Digitize_Buffers()
                    Services internal buffers while digitizing.
Access_Digitized_Data_In_Ram_Buffer()
                    Provides access to digitized data (even
                    during acquisition).
```

Simple digitizing is illustrated nicely in Example#2. In summary, to digitize, one must:

1. Call `DisableAllChannelsForDigitizing()` to disable all channels for digitizing.
2. Specify which channels are to be digitized by calling `LoadChannelAddress()` and `EnableChannelForDigitizing()` for each digitize channel.
3. Specify timing parameters (e.g. sample rate) with `Set_iNet_TIMING_Parameters()`.
4. Specify trigger parameters with `Set_iNet_TRIGGER_Parameters()`.
5. Tell the instruNet driver to start digitizing with `PRESS_iNet_BUTTON( iNetCM_BtnPress_Record_Start )`.
6. Periodically (e.g. 4 times per second) call `Service_All_iNet_Digitize_Buffers()` to provide the instruNet Driver time to service internal buffers (this is mandatory).
7. Call `Access_Digitized_Data_In_Ram_Buffer()` to access digitize data for each channel.

Support Functions

Additional functions defined and described in C file `INET_INT.C`, and in Visual Basic file `INET_Interface.bas`, are listed as follows:

UTILITY FUNCTIONS

`iNet_Peek_int16()`	*Reads 16bit integer number from a specific logical address.*
`iNet_Peek_int32()`	*Reads 32bit integer number from a specific logical address.*
`iNet_Peek_flt32()`	*Reads 32bit floating point number from a specific logical address.*
`iNet_Poke_int16()`	*Writes 16bit integer number to a specific logical address.*
`iNet_Poke_int32()`	*Writes 32bit integer number to a specific logical address.*
`iNet_Poke_flt32()`	*Writes 32bit floating point number to a specific logical address.*
`iNet_Get_VarPtr()`	*Returns a pointer to the passed variable.*
`iNet_memcopy()`	*Copies memory block from one place to another.*

ADVANCED FIELD READ/WRITE ROUTINES

`iNet_int32()`	*Reads or writes to a field via a 32bit signed integer variable.*
`iNet_uint32()`	*Reads or writes to a field via a 32bit unsigned integer variable.*
`iNet_flt32()`	*Reads or writes to a field via a 32bit floating point variable.*
`iNet_cString()`	*Reads or writes to a field via a C string variable.*
`iNet_pString()`	*Reads or writes to a field via a Pascal string variable.*
`iNet_DLL()`	*Reads or writes to a field via any type of variable.*

DRIVER ROUTINES

`Load_instruNet_Driver()`	*Loads instruNet driver into memory.*

```
CloseDriverAndReleaseDriverRam()
                    Closes instruNet driver and releases memory.
Show_ALERT_if_hit_iNet_Error()
                    Shows an alert if instruNet hit an error.
Show_Simple_Alert() Displays a message in an alert dialog box.
Get_iNet_Error()    Gets error code to last instruNet function
                    call.
Get_Last_iNet_Call() Returns pointer to struct with params to
                    last iNet call.
```

Interface Files

The instruNet disk includes interface files for C and Visual BASIC that enable your program to call the above listed functions. No compiler object files are used; therefore, you are not at the mercy of a specific version of a specific compiler on a specific computer. Instead, you simply add the following glue source code to your program:

VB Files	C Files	Interface Description
INET_Interface.bas /INET_Common_Code.bas	INET_INT.C	*Contains low level source code that interfaces to the instruNet driver.*
INET_Declarations.bas	INET_INT.H	*Contains many low level enums and #defines that support instruNet.*
INET_Macros.bas	INET_MCS.H	*Contains macros that help set/read instruNet fields.*

Every instruNet C program must include the following files: `INET_INT.C`, `INET_INT.H`, and `INET_MCS.H`.

Every instruNet Visual Basic program must include the following files: `INET_Interface.bas, INET_Common_Code.bas, INET_Declarations.bas,` and `INET_Macros.bas`.

Programming Examples

The instruNet disk includes example programs in Visual Basic and C. The C Example #1 and VB Example #1 do the same thing, yet just in different languages. In fact, they do many of the same things that are done in Ch 2 Tutorial. For example, in Ch 2, one is asked to turn on a low pass filter by selecting a popup menu. Example#1 will do the same thing with the iNet() function call. With instruNet, each task can be done automatically under program control, or manually in the instruNet World window. This will become more clear as you work with the example programs. The instruNet disk includes the following example programs:

C Files	VB Files	Example Description
INET_EX1.C	iNetExample1_fp.frm iNetExample1.bas	*This is a lengthy and comprehensive example that shows how to call almost every instruNet function in a text window-based environment.*
INET_EX2.C	iNetExample2_fp.frm iNetExample2.bas	*This is a simple example that shows how to read and write instruNet fields and how to digitize.*

instruNet Data Types

instruNet defines its own data types that allow you to keep your code platform, machine, and operating system independent. instruNet data types are defined in the file `INET_INT.H`. An example of an instruNet data type definition is:

```
typedef unsigned short iNetUINT16;  /* 16bit unsigned integer */
```

Always use instruNet data types when calling the instruNet driver and macros.

In this manual, the following are used to refer to variable types:

iNetINT8	signed 8bit integer, -128 to +127.
iNetUINT8	unsigned 8bit integer, 0 to +255.
iNetINT16	signed 16bit integer, -32768 to +32767.
iNetUINT16	unsigned 16bit integer, 0 to +65536.
iNetINT32	signed 32bit integer, -2,147,483,648 to +2,147,483,647.
iNetUINT32	unsigned 32bit integer, 0 to +4,294,967,295.
iNetFLT32	32bit floating point number

instruNet Macros

instruNet defines a number of macros for the more common driver calls. The macros are defined in file `INET_MCS.H`. The macros are platform, machine and operating system independent. An example of a macro call is:

```
OPEN_instruNet_WINDOW( instruNetCM_OpenWindow_Network );
```

which when called will open the Network Page of instruNet. The Network Page could also have been opened by directly calling the instruNet C function:

```
iNet((iNetUINT8) netNum_DRIVER, (iNetUINT8)
   deviceNum_CONTROLLER, (iNetUINT8) moduleNum_1stModule,
   iNetUINT8) driver_ChanNum_OpenWindow, sgt_General,
   fldNum_General_valueEu, intention_setValue,
   instruNetDT_INT16, (void *) ((gINT16TempArg =
   specificPage) ? &gINT16TempArg : &gINT16TempArg));
```

Example Code

Example#1 does the following things using the instruNet interface functions. C source code is shown in `Courier font`.

1. Load instruNet Driver
   The C code below calls `Load_instruNet_Driver()` to load the instruNet Driver, and to get the number of installed controller cards. If the driver does not load properly, an error is returned and `Show_ALERT_if_hit_iNet_Error()` displays a dialog box with an error code. Please consult Appendix II for more information on error codes.

```
iNetError e;
iNetINT16 driverIsInstalledOK, numNetworks;
e = Load_instruNet_Driver(TRUE /* reset_instruNet */,
           &driverIsInstalledOK, &numNetworks);
if (e != iNetErr_None)  {
    Show_ALERT_if_hit_iNet_Error(e);  return 0;  }
```

2. Tell the instruNet Driver to open the Network Page Window
   The C code below tells the driver to open the Network Page Window. From the Network Page, fields can be viewed and set following the procedures in *Chapter 2 instruNet Tutorial.* If a non zero error code is returned the program will jump to an exit routine.

```
e = OPEN_instruNet_WINDOW( instruNetCM_OpenWindow_Network );
if (e) { goto Exit; }
```

3. Read several voltage inputs and set a voltage output
   The next few lines of code read several voltage inputs and write to a voltage output. They assume a Model 100 is attached to the 1st network controller card.

4. Print the values for the first 5 channels on instruNet
   The C code below calls the function `Print_iNet_Channels()` which reads one value from each of the first five input channels of an instruNet Network, and prints them to the console window. The function call is defined in file `INET_EX1.C`.

```
e = Print_iNet_Channels(5);
if (e) { goto Exit; }
```

6. Print the first 3 Fields
   The C code below calls the function `Print_iNet_Fields()` which scans the network and prints the values of the first 5 fields that it finds. The function call is defined in file `INET_EX1.C`

```
e = Print_iNet_Fields(3);
if (e) { goto Exit; }
```

7. Read and write instruNet Fields
   The C code below calls the function `ReadWriteFields_iNet()` prompts the user for a field address, displays the current value of the field and allows the user to change the field value. The function call is defined in the program `INET_EX1.C`.

```
e = ReadWriteFields_iNet();
if (e) { goto Exit; }
```

8. Digitize some analog input channels
   The C code below calls the function `SimultaneouslyDigitizeAndAnalyze()` which digitizes several channels. When writing code that acquires data seamlessly it is important to continuously call `Service_All_iNet_Digitize_Buffers()` while the data acquisition is running. This function call is defined in the file Example#1 file.

```
e = SimultaneouslyDigitizeAndAnalyze();
if (e) { goto Exit; }
```

9. Modify the Example source code to meet your own needs.

Tutorial Summary

In summary, the Programming Tutorial will involve the following steps:

1. Make sure you have done Ch2 Tutorial in its entirety.

2. Install your programming environment on your hard disk, load an example program shipped with your Programming Language, compile, and then run to verify that your Programming Environment is set up properly.

3. Create a new Folder/Directly on your hard disk. Make a copy of the instruNet example program and place it into this folder, along with include files.

4. Compile and link the code. If you have any compile or link errors, please use the source code to debug the system -- all source code is provided.

5. Run the example programs to verify that the compiler, example files, driver, and computer are all working well together.

6. Read the example program source code and comments to get a feel for instruNet programming.

Getting Started

To do the above steps with the programming language of your choice, please jump to the appropriate "Getting Started with ..." in the following pages.

WORKING WITH ANY C COMPILER (Macintosh or Windows 95)

instruNet provides C source code that is designed to run on virtually any C compiler for the Macintosh and Windows 95.

To run the example instruNet C code, we recommend that you create a project that supports the printf text console (not needed with Windows), C, the Operating System routines, and ANSI routines. At a bear minimum, you would need to include the following files into a project in order to run an instruNet Example:

`INET_EX`*`N`*`.C`	Contains Example#*N* code (use one example .c file at a time)
`INET_INT.C`	Contains interface to instruNet Driver (includes files: `INET_MCS.H, INET_INT.H`)
---	
ansi library	Contains ANSI subroutines
os library	Contains interface to Operating System
console library	Supports printf() text window (only use with Macintosh)

To compile the instruNet example code and run it, you must:

1. Install the instruNet software onto your computer following the directions in Chapter 1 *Installation.*

2. Make sure you have the correct version of the instruNet Driver installed on your computer.

3. Create a new folder, called "instruNet Example", and place 2 folders inside it called "instruNet C Source" and "End User Source". Copy (i.e. duplicate) the following files and place them into the "instruNet C Source" folder:

   `INET_INT.C, INET_MCS.H, INET_INT.H, (INET_EX1.C or INET_EX2.C)`

4. Create a new project that supports the ANSI library and the console window.

5. Add `INET_INT.C` and `INET_EX`*`N`*`.C` to the project.

6. Compile and run.

   `INET_INT.C` and `INET_EXN.C` are designed to run without a prefix file pulled in before them (i.e. prefix option in the .... dialog). If you do have a prefix that is automatically pulled in, you might get some compiler errors and need to debug it a little. In general, `INET_INT.C` and `INET_EXN.C` can run with either 4 or 2 byte int's (it assumes short's are 2bytes), 8 to 12 byte doubles, different struct packing schemes, etc. These 2 files are designed to be portable across different processors, different operating systems, and different compilers.

   The `INET_INT.C` file is all you need to add to your project to run instruNet. It uses the `INET_MCS.H` and `INET_INT.H` include files. The `INET_EX1.C` file contains many useful routines, yet you might not want the console to run, and therefore you might want to modify `INET_EX1.C` to your own taste.

   Some lines of code in the example program open the instruNet World window, and pass control to instruNet World (until the user closes the instruNet World window to return back to the example program). Don't let this freak you out.

7. Read the example program source code and comments to get a feel for instruNet programming. Step through the source code with the debugger to see it runs on a line-by-line basis. Read the documentation in the `INET_MCS.H` and `INET_INT.H` include files.

Getting Started with Macintosh Symantec C/C++

Compatibility

instruNet interface for Symantec C/C++ is compatible with Symantec C/C++ for 68k Macintosh and PowerPC version 7.0 or 8.0. Minimal system requirements are a 68020 Macintosh with at least 8 Meg of RAM and System 7.0 or newer. Recommended system requirements are a 68040 or PowerPC Macintosh with 16 Meg of RAM. System 7 or newer and Color QuickDraw are also required.

Getting Started

To get started with Symantec C/C++, please do the following steps:

1. Make sure you have done *Ch1 Installation* and *Ch2 Tutorial* in its entirety.

2. Install Symantec C/C++ onto your computer, launch the compiler, and then run an example Symantec C/C++ project to verify that your compiler is set up properly. You can try running the "Hello World" project or any of the other Symantec supplied projects. Close the example project.

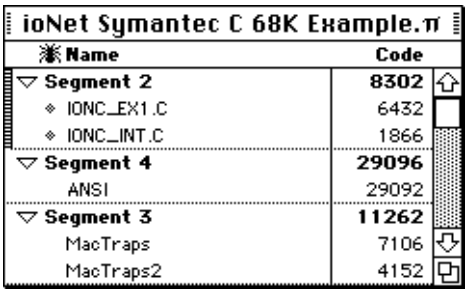
3. Create a new folder, called "instruNet Symantec C Example", and place 2 folders inside it called "instruNet C Source" and "End User Source". Copy (i.e. duplicate) the following files and place them into the "instruNet C Source" folder:

   `INET_INT.C, INET_MCS.H, INET_INT.H, (INET_EX1.C or INET_EX2.C)`

4. Select New Project... from the File menu. Select "Empty Project" in the New Project popup (or select an "ANSI C" project stationary), give the project a name (e.g. "instruNet Symantec C Example)" and put it into the instruNet example

folder created in step 3. After creating the project, choose Project Type in the Project menu and then set the Partition (i.e. application file) size to 1500KB. Also, turn the Debugger On in the Project menu (unless you want to use less ram at run time and do not want to step though the source code and read the documentation).

5. Add the files `INET_INT.C` and `INET_EXN.C` to the project. If working on a 68K code, in a separate segment add the Symantec MacTraps and MacTraps2 Libraries (in the "Macintosh Libraries:68K Libraries" folder) and in another segment add the Symantec ANSI Library (in the "Standard Libraries" folder). If developing ppc code, add the ppc equivalents to your project.



68K Symantec C Project

6. Select Run from the Project menu. The `main()` in file `INET_EXN.C` will first run instruNet World. You can view and change fields and record data following the directions in *Chapter 2 Tutorial*. When you quit instruNet World, the C program will put you in the console window where you can read and write individual fields. To exit the console window select Quit from the file menu. Some lines of code open the instruNet World window, and pass control to instruNet World (until the user closes the instruNet World window to return back to the example program). Don't let this freak you out.

7. Read the example program source code and comments to get a feel for instruNet programming. Step through the source code with the debugger to see it run on a line-by-line basis. Read the documentation in the `INET_MCS.H` and `INET_INT.H` include files.

8. Modify the Example source code to meet your own needs.

Getting Started with Mac metrowerks CodeWarrior C/C++

The instruNet interface for metrowerks CodeWarrior C/C++ is compatible with metrowerks CodeWarrior for 68k Macintosh and PowerPC. Minimal system requirements are a 68020 Macintosh with at least 8 Meg of RAM. Recommended system requirements are a 68040 or PowerPC Macintosh with 16 Meg of RAM. System 7 or newer are also required.

Getting Started

instruNet can run on any version of metrowerks C greater than 7.0 on a 68K or Power Macintosh. To get started with CodeWarrior C/C++, please do the following steps:

1. Make sure you have done *Ch1 Installation* and *Ch2 Tutorial* in its entirety.

2. Install metrowerks CodeWarrior onto your computer, launch the compiler, and then run an example CodeWarrior project to verify that your C/C++ compiler is

set up properly. You can try running the "MW Hello World" project or any of the other metrowerks supplied projects. Close the example project.

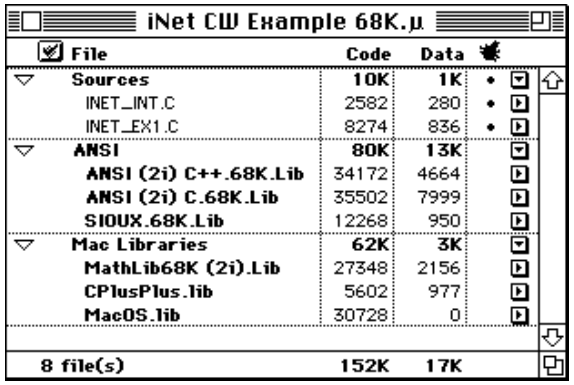
3. Create a new folder, called "instruNet CodeWarrior C Example", and place 2 folders inside it called "instruNet C Source" and "End User Source". Copy (i.e. duplicate) the following files and place them into the "instruNet C Source" folder:

   `INET_INT.C, INET_MCS.H, INET_INT.H, (INET_EX1.C or INET_EX2.C)`

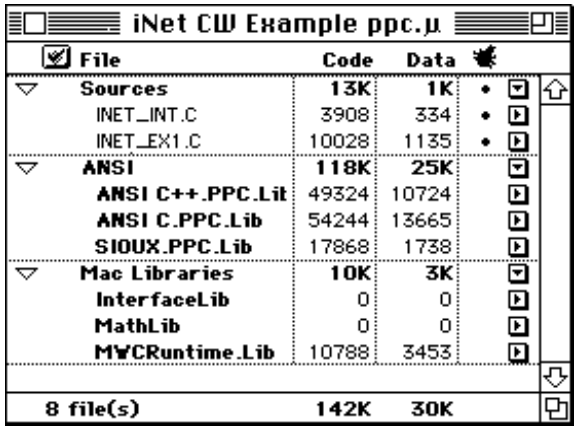
4. Select New Project... from the File menu. In the Project Stationary popup, select `ANSI 68k C/C++.µ` if compiling for 68K and `ANSI PPC C/C++.µ` if compiling for ppc. Specify a project name (e.g. "instruNet CodeWarrior C Example"), and then place the project into the instruNet example folder created in step 3. After creating the project: choose Preferences under Edit, select "68K/PPC Project" and set the Preferred and Minimum Heap (i.e. application file) size to 1500KB. Also, select Enable Debugger in the Project menu to turn on source level debugging (unless you want to use less ram at run time and do not want to step though the source code and read the documentation).

5. Add the files `INET_INT.C` and `INET_EXN.C` to the project.

6. Select Run from the Project menu. The `main()` in file `INET_EX1.C` will first run instruNet World. You can view and change fields and record data following the direction in *Chapter 2 Tutorial*. When you quit instruNet World the program will put you in the console window where you can read and write individual fields. To exit the console window select Quit from the file menu. Some lines of code open the instruNet World window, and pass control to instruNet World (until the user closes the instruNet World window to return back to the example program). Don't let this freak you out.



68K CodeWarrior C Project



PPC CodeWarrior C Project

7. Read the example program source code and comments to get a feel for instruNet programming. Step through the source code with the debugger to see it run on a line-by-line basis. Read the documentation in the `INET_MCS.H` and `INET_INT.H` include files.

8. Modify the Example source code to meet your own needs.

Getting Started with Microsoft Visual Basic ≥4.0 for Windows 95/NT

Compatibility

The instruNet interface for Visual Basic is compatible with VB Version ≥ 4.x, which requires a ≥ 80386 PC / PC Compatible Computer running Windows 95 and ≥8 MB Ram. A BASIC for the Macintosh is not supported by instruNet.

Every instruNet Visual Basic program must include the following files: `INET_Interface.bas, INET_Common_Code.bas, INET_Declarations.bas, and INET_Macros.bas.`

Getting Started

To get started with Visual BASIC ≥ 4.x, please do the following steps:

1. Make sure you have done Ch2 Tutorial in its entirety.

2. Install Visual Basic onto your hard disk, load an example program, compile, and then run to verify that your BASIC is set up properly.

3. Duplicate the "instruNet VBasic Examples" directory in the "instruNet" directory. We will run/modify the files in the duplicate copy. This directory contains the following sub-directories:

`VB Example1`	example program #1
`VB 2Ch Oscilloscope`	example oscilloscope program with a nice display
`VB Common Source`	common source code files
`VB Direct To Excel`	digitize directly to Excel Version ≥8 example

4. Run one of the example programs. If you have any errors, please use the source code to debug the system -- all source code is provided. Some lines of code open the instruNet World window, and pass control to instruNet World (until the user closes the instruNet World window to return back to the example program). Don't let this freak you out.

5. Run an example program to verify that the compiler, example files, driver, and computer are all working well together.

6. Read the example program source code and comments to get a feel for instruNet programming.

7. Modify the Example source code to meet your own needs.

Getting Started with Microsoft C/C++ 4.x for Windows 95/NT

Compatibility

The instruNet interface for Microsoft C/C++ is compatible with Version 4.x, which requires a ≥ 80386 PC / PC Compatible Computer running Windows 95 and ≥8 MB Ram.

Getting Started

To get started with Microsoft C/C++, please do the following steps:

1. Make sure you have done Ch2 Tutorial in its entirety.

2. Install Microsoft C/C++ onto your hard disk, load an example program, compile, and then run to verify that your C/C++ is set up properly.

3. Duplicate the "Project MS 4.x C Example" directory in the "instruNet Win95 Disk" directory. It contains the following source files: `Inet_int.c`, `Inet_int.h`, `Inet_Ex1.c`, `Inet_Ex2.c`, and `iNet_mcs.h`. We will run/modify the files in the duplicate copy.

4. Open "`Inet32_ExampleN.mdp`" with the Microsoft Developer Studio, select Set Default Configuration under Build, choose Win32 Debug, press OK, select Debug > Step Into under Build and watch it compile. You should not get any compiler errors or warnings. If it builds properly, it will begin to run under the debugger. Press the Step Over under Debug (i.e. F10) button to step through the example program.

5. Step through the example program to verify that the compiler, example files, driver, and computer are all working well together. Some lines of code open the instruNet World window, and pass control to instruNet World (until the user closes the instruNet World window to return back to the example program). Don't let this freak you out.

6. Read the example program source code and comments to get a feel for instruNet programming.

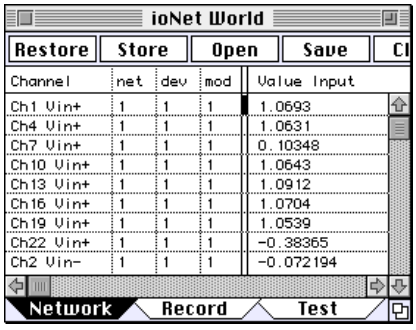
7. Modify the Example source code to meet your own needs.

8. If you want to operate instruNet from another C program, copy files `Inet_int.c`, `Inet_int.h`, and `iNet_mcs.h` to your target project source directory, add `Inet_int.c` to your project, call any of the `iNet_mcs.h` macros from your own source code, call any of the `Inet_int.c` subroutines from your own source code, copy any of the useful subroutines in `Inet_ExN.c` into your own source code, and away you go.

5 instruNet World Program Reference

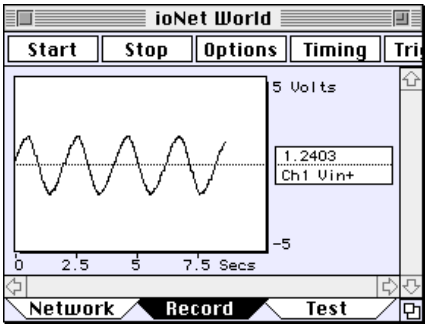
This chapter provides a detailed reference of the features within the instruNet World Application Program, which is what we believe the 21st Century Strip Chart Recorder/Oscilloscope will look like. This chapter is intended to be used as a reference, whereas *Chapter 2 Tutorial* is recommended to teach the basics. To install instruNet World, please follow the directions in the Software Installation section of *Chapter 1 Installation* .

The Network Page



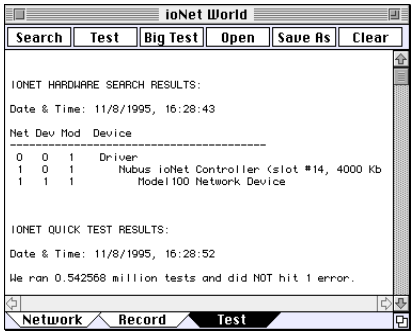
The Network Page is used to view and set parameters within an instruNet network. This page provides a spreadsheet-like format to scroll vertically through channels (i.e. sensors), and horizontally through the settings for each channel. At any time, one can click on a cell to open the Probe dialog, which is used to view and modify individual settings.

The Record Page



The Record Page is used to Start, Stop, View in real-time, Save to disk, and Load from Disk waveforms. Only channels that have been turned "on", via the Probe dialog, are recorded. The sample rate and number of points digitized per channel are specified by pressing the Setup button. The Trigger is specified by pressing the Trigger button.

The Test Page



The Test Page is used to determine what instruNet hardware is attached to your computer, and to test all instruNet hardware and software. After each test, a report is printed to a miniature text editor within the Test Page. The user can then type notes into this window, and save it to disk as a TEXT file.

Figure 5.1 instruNet World Pages

Three Pages

instruNet World is an application program that can manage, monitor and operate an instruNet hardware network. This network can be used to digitize long continuous waveforms, spool them to disk, view incoming waveforms in real-time and then allow post acquisition viewing. instruNet World is included, free of charge, with all instruNet Controller boards and does not require programming experience -- it is as easy to use a simple word processor (relax !). This chapter describes the three instruNet pages, as illustrated in Figure 5.1. Each page is selected by pressing a Tab at the bottom of the window.

The Network Page

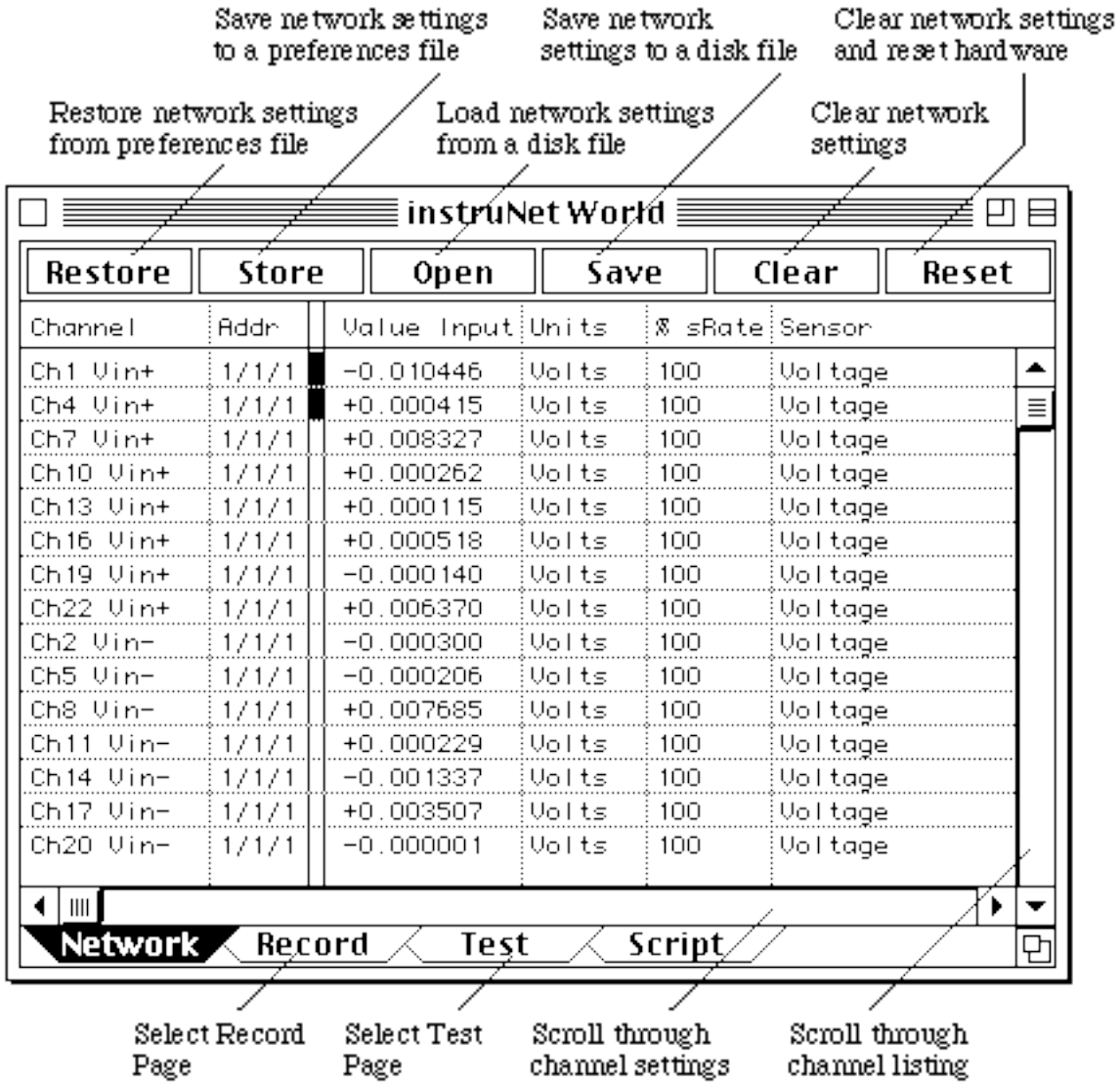

Save network settings to a preferences file
Save network settings to a disk file
Clear network settings and reset hardware
Restore network settings from preferences file
Load network settings from a disk file
Clear network settings
instruNet World
Restore
Store
Open
Save
Clear
Reset
Channel | Addr | Value Input | Units | % sRate | Sensor
Ch1 Vin+ | 1/1/1 | -0.010446 | Volts | 100 | Voltage
Ch4 Vin+ | 1/1/1 | +0.000415 | Volts | 100 | Voltage
Ch7 Vin+ | 1/1/1 | +0.008327 | Volts | 100 | Voltage
Ch10 Vin+ | 1/1/1 | +0.000262 | Volts | 100 | Voltage
Ch13 Vin+ | 1/1/1 | +0.000115 | Volts | 100 | Voltage
Ch16 Vin+ | 1/1/1 | +0.000518 | Volts | 100 | Voltage
Ch19 Vin+ | 1/1/1 | -0.000140 | Volts | 100 | Voltage
Ch22 Vin+ | 1/1/1 | +0.006370 | Volts | 100 | Voltage
Ch2 Vin- | 1/1/1 | -0.000300 | Volts | 100 | Voltage
Ch5 Vin- | 1/1/1 | -0.000206 | Volts | 100 | Voltage
Ch8 Vin- | 1/1/1 | +0.007685 | Volts | 100 | Voltage
Ch11 Vin- | 1/1/1 | +0.000229 | Volts | 100 | Voltage
Ch14 Vin- | 1/1/1 | -0.001337 | Volts | 100 | Voltage
Ch17 Vin- | 1/1/1 | +0.003507 | Volts | 100 | Voltage
Ch20 Vin- | 1/1/1 | -0.000001 | Volts | 100 | Voltage
Network
Record
Test
Script
Select Record Page
Select Test Page
Scroll through channel settings
Scroll through channel listing

Figure 5.2 The Network Page

Overview

The Network Page is used to view and modify Fields that control all Analog, Digital, and Timer I/O channels within an instruNet network. These Fields do things like define the cut-off frequency of a digital low pass filter, set the range of a voltage input, or define the type of sensor that is connected to the input.

Surfing The Net

After starting the instruNet World application the Network Page is selected by clicking the Network tab at the bottom of the instruNet World window. Your Network Page will resemble Figure 5.2 although your rows and columns may differ depending on what is attached to your network.

Each row corresponds to a Channel (e.g. typically one sensor is attached to each voltage input channel), and the columns are used to display the settings of Fields that pertain to each Channel. The horizontal scroll bar is used to scroll through the Fields, and the vertical scroll bar is used to scroll the Channels.

Modifying Fields

To change a Field, simply click on its cell. The Probe dialog will pop open and it is here that one can view and modify all Fields within the network. Typical networks will house thousand of Fields yet their default values, in most cases, will suffice (relax !). For a detailed description of the various settings, please refer to *Chapter 8 Settings Reference* of this manual.

Channels

Figure 5.3 shows an expanded view of the Network Page. The Channel names appear in the left-most column, and the real-time values of each channel are under "Value Input". The "network address" (i.e. network number, device number, and module number) of each channel is shown in column 2. The first channel in the first module of the first device attached to the first Controller will have a physical network address of {1,1,1,1}. The table header is optimized for the upper-most visible channel, and therefore may change slightly when scrolling vertically.

Turning A Channel On

To "enable" a channel for digitizing (so you can see its signal in the Record Page), one must click on the small vertical rectangle after the network address. It will darken to indicate that the channel will be digitized when the Start button is pressed in the Record Page. Clicking it again will turn it "off". Figure 5.3 shows Channel "Ch1 Vin+" as being "turned On".

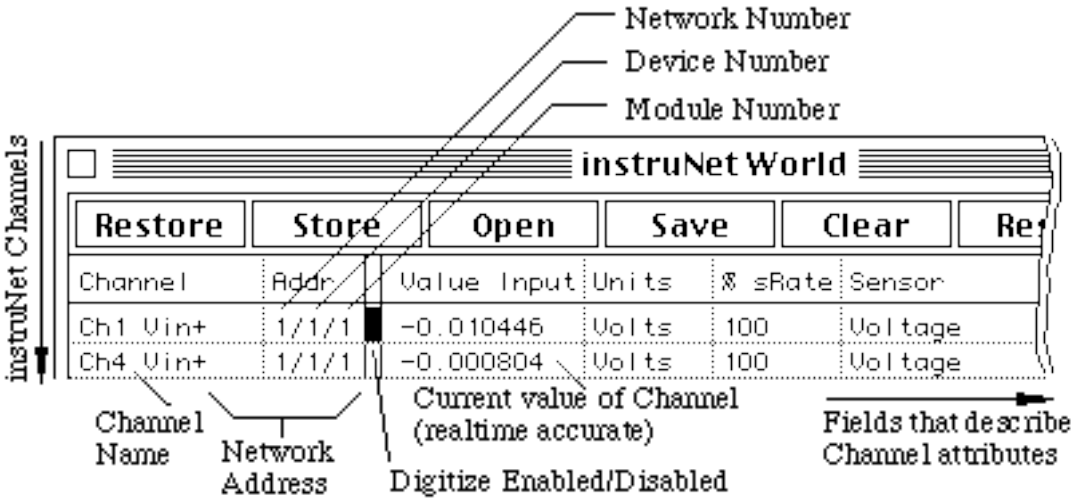


Figure 5.3 Expanded view of the Network Page

Pull Down Menus

Pull down menus vary depending on your operating system. For example, the Macintosh version of instruNet World provides the minimum menus of Quit under File; and Cut, Copy, & Paste under Edit. Control keys (e.g. Control C, or Command C for Copy-To-Clipboard) are also supported in the Test Page's text window.

Saving Your Configuration

The buttons at the top of the Network Page are used to save Field settings to disk, load them from disk, Clear them to their default values, and to Reset hardware. In a typical session, the user will modify several Fields (e.g. turn on 2 channels and set their filter and sensor parameters), save these settings to disk via the Save button, exit instruNet World, run instruNet World a week later, and reload these settings via the Open button. When the state of instruNet World is saved to disk, you are saving the Fields that have changed from their default values. When you load the state back in, instruNet will first set all Fields to their default values, load the file, and then update the Fields that were changed. -- therefore, these "state" files are typically small (e.g. several KB). In fact, you can open these TEXT files with a Word Processor or Spreadsheet program to glean a sense as to how instruNet internally stores Fields settings. instruNet keeps all state in Fields, therefore, it is not necessary to save anything else (except waveform data) in order to get you back to where you were. Saving waveform data is done independently via the Save and Open buttons at the top of the Record Page. The Network Page manages Fields, whereas the Record Page manages waveforms.

Reconnecting With A Changed Network

If your instruNet Network changes (e.g. you physically pull out 1 device, and then install 2 more), the stored Field settings may no longer apply to your new network. instruNet does its best to "reconnect" and will alert you to any discrepancies, yet it is always a good idea check your settings after physically changing your network. Typically, adding hardware will not cause discrepancies, since you are adding Fields that will be kept at their default values when you load in the settings to "other" fields. However, if you physically reduce your instruNet network (or replace one device with another), a settings file may try to set a field that no longer exist, and in this case, instruNet might show an alert that states it is having a little trouble.

Buttons

The Network Page has the following buttons at the top of the window:

Restores the state of all Fields that existed when the Store button was last pressed. Restore loads a settings file that is kept in an operating system preferences directory. You must press Store to save this file before you press Restore. Restore and Store are very similar to Open & Save, except Open & Save show a File dialog that enables the user to pick the file name & directory; whereas Restore & Store always go to the same file & directory and do not bother the user with file issues.

Saves a file to disk that contains the state of all Fields. This preferences file is stored within the operating system directory, and is reloaded by pressing the Restore button. File Save and File Open dialogs are not used since the file name and directory are always the same.

Saves a file to disk that contains the state of all Fields. The user specifies the file name and location within the standard File Save dialog.

Loads a file from disk that contains the state of all Fields. The user must pick a previously stored settings file via the standard File Open dialog.

Clear	Clears all Field settings to their default values.
Reset	Resets all instruNet hardware and Clears all Fields to their default values.
Calibrate	Calibrates all instruNet hardware. To set up this button to also balance strain gages at 0uStrain, press the Setup button in the Record page, press the More button, select Window in the Settings popup, select Bal Gages in the Cal Btn field, and then exit the dialogs.

The Record Page

The Record Page is used to view recorded (i.e. digitized) waveforms in real-time, store these waves to disk, load them from disk, and scroll through them post acquisition. The Record page, illustrated below, is chosen by pressing the Record tab at the base of the instruNet World window.

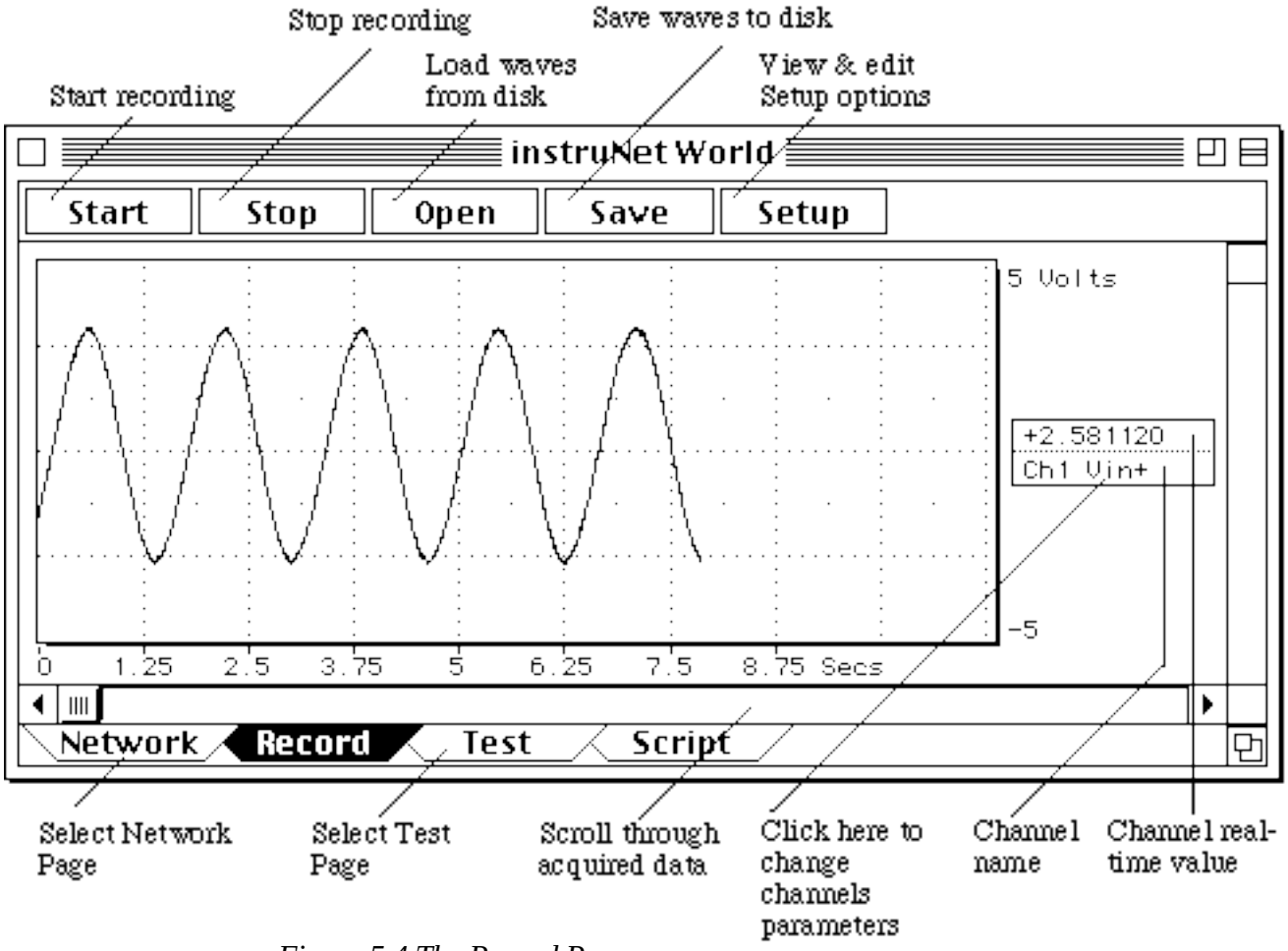


Figure 5.4 The Record Page

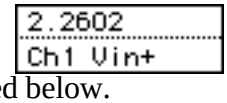
Setting Up A display is shown for each Channel that has previously been turned On. For

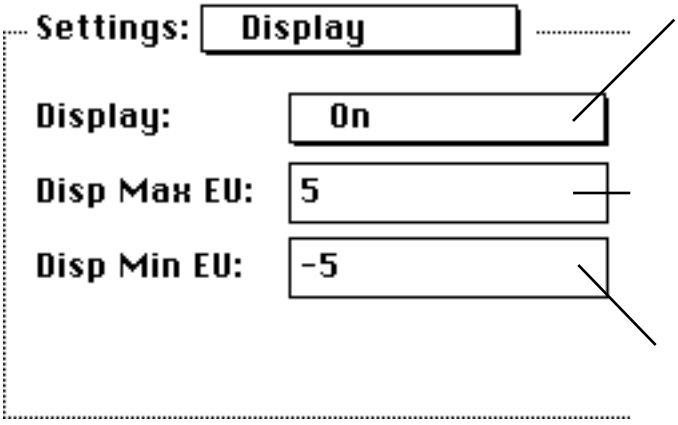
Channels

example, in Figure 5.4, one channel (i.e. "Ch1 Vin+") has been turned On. To learn how to turn Channels On and Off, please consult the "Turning A Channel On" discussion earlier in this chapter. The height of each display is determined by the number of ON Channels, and the height of the window. In some cases, it is helpful to resize the window (i.e. drag the lower left corner of window). The minimum display height is about 2cm, therefore if more displays exist than there is room, only a subset will be shown, and the user can vertically scroll through the viewed subset with the vertical scroll bar. The horizontal scroll bar is used to horizontally scroll through waveforms, post-acquisition, and consequently sets the time of the left edge for all displays.

Setting Up Displays

To adjust the engineering units value that corresponds to the top and bottom of each display, click on its label (pictured to the left) at the display right edge. The Display dialog will open, as illustrated below.





If "On", the channel is digitized (and displayed, if the Record page is open) when the START button is pressed; otherwise, it is dormant while Digitizing.

This corresponds to the vertical axis value, in engineering units, at the top of a Display.

This corresponds to the vertical axis value, in engineering units, at the bottom of a Display.

Figure 5.5 Display settings

Oscilloscope or Strip Chart Scan Mode

instruNet supports two Scan Modes, Oscilloscope and Strip Chart, one of which is selected in the Scan Mode popup within the Setup Dialog. Oscilloscope digitizes individual Scans (similar to a real Oscilloscope), whereas Strip Chart links a set of scans together, seamlessly, to form one long waveform (the user does not notice the individual Scans), as illustrated in Figures 5.6 and 5.7. Put a little differently, Oscilloscope waits for a Trigger (specified in the Trigger dialog) before digitizing each Scan, and Strip Chart only waits for a Trigger before digitizing the first Scan.

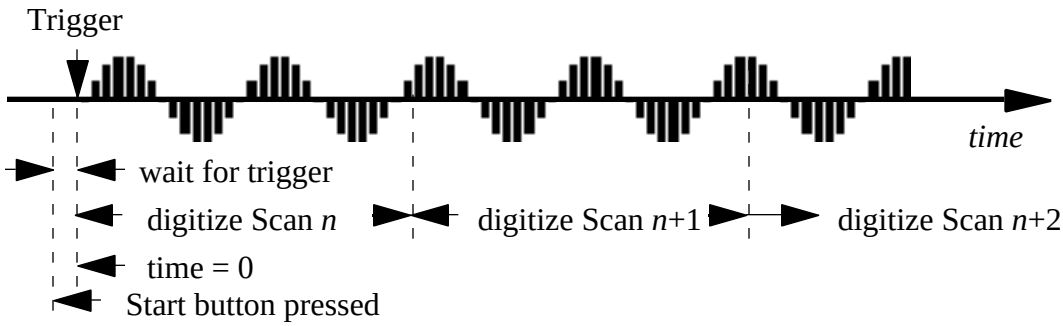


Figure 5.6 Strip Chart Recorder Mode

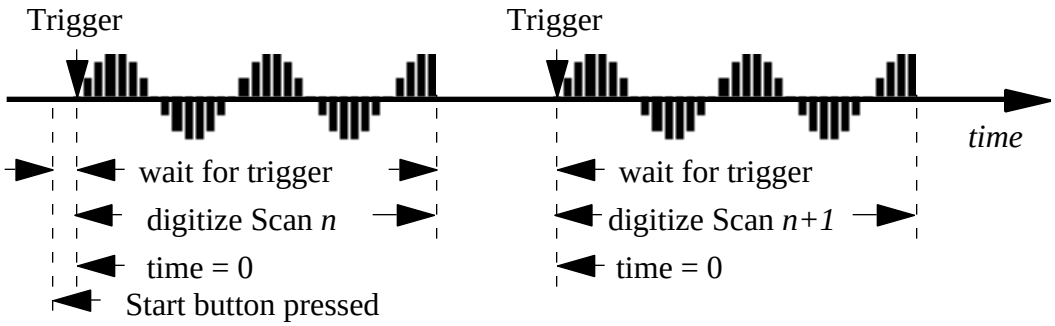


Figure 5.7 Oscilloscope Mode

Oscilloscope mode has two variations, Oscilloscope and Oscillo Queued. Both Oscilloscope and Oscillo Queued acquire and store scans of data in a buffer for processing. In Oscilloscope mode the most recent scan of data in the buffer will always be returned for processing (first in, last out). In Oscillo Queued mode the scans are retrieved from the buffer in sequence (first in, first out).

A typical example of how a data acquisition program using Oscilloscope mode would work is as follows: first the program would wait for the user specified trigger condition and then acquire the first scan of data; next the program would process the acquired scan (i.e. display, analyze, save to disk) while instruNet continued to acquire scans in the background based on the trigger condition, while the processing is going on; next the program would retrieve the most recent scan from the queue, ignoring older scans.

In the Oscilloscope case the scan returned from the buffer will always be the most recently acquired scan, and all other scans in the buffer will be ignored. For example if each scan were 10ms long, the trigger condition was set to none, and the processing took 40ms, then the program would retrieve the first scan, process it and then retrieve the 4th of the 4 queued scans (i.e. the most recent scan) that had accumulated in the buffer while it was processing the first scan. The 3 other older scans would be discarded.

If the example above were done in Oscillo Queued it would work as follows: first the program would wait for the user specified trigger condition and then acquire the first scan of data; next the program would process the acquired scan (i.e. display, analyze, save to disk) while instruNet continued to acquire scans in the background based on the trigger condition; next the program would retrieve the next scan in the queue (i.e. the acquired scan that immediately followed the first acquired and processed scan). In Oscillo Queued mode triggered scans continue to accumulate in the queue and are returned in order.

In Oscillo Queued mode all scans are returned by instruNet for processing but if a lot of processing is required between scans the instruNet buffer can eventually overflow at which point instruNet will return an error message. In Oscilloscope mode the most recent scan is always returned and others are discarded. While scans are discarded in Oscilloscope mode the buffer will not overflow. If the time to process data takes less than the time of a scan then both modes will behave identically. Figure 5.8 below shows the difference between Oscilloscope and Oscillo Queued modes.

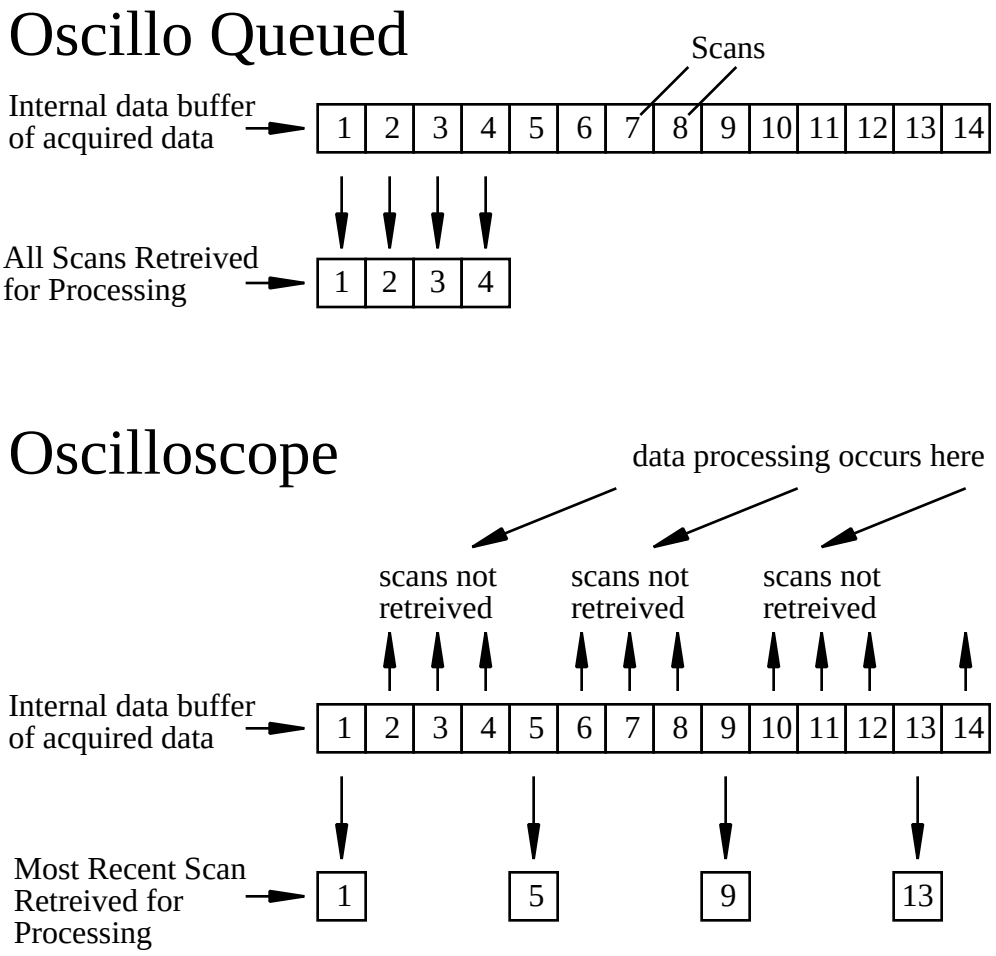

Oscillo Queued
Scans
Internal data buffer of acquired data
1 2 3 4 5 6 7 8 9 10 11 12 13 14
All Scans Retreived for Processing
1 2 3 4
Oscilloscope
data processing occurs here
scans not retreived
scans not retreived
scans not retreived
Internal data buffer of acquired data
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Most Recent Scan Retreived for Processing
1
5
9
13

Figure 5.8 Oscilloscope and Oscillo Queued Modes

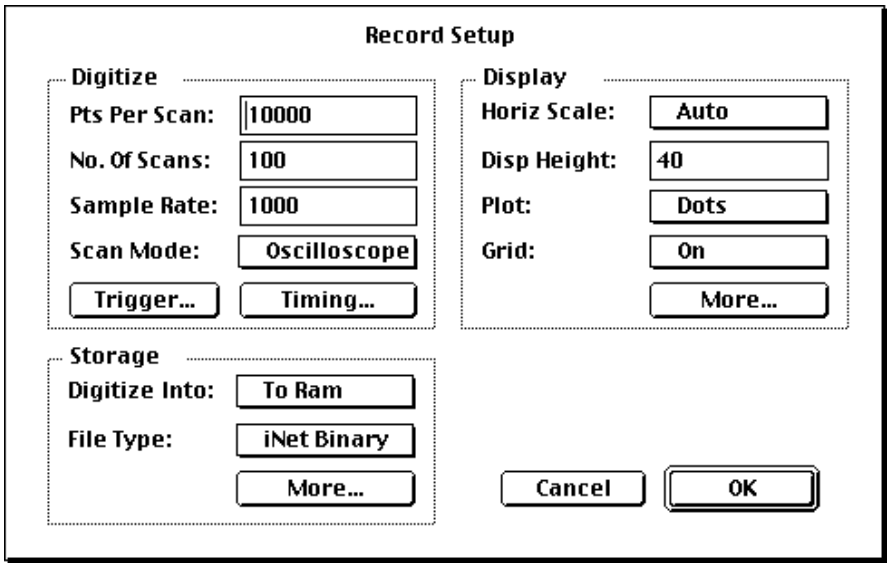


Figure 5.8b The RecordSetup Dialog

Record Setup The Record Setup dialog, illustrated in Figure 5.8b, is used to set the base sample rate, the number of points to be acquired per Scan, the number of Scans to be acquired, the recording mode (i.e. oscilloscope or strip chart recorder), the storage mode, and the display mode. This dialog is described in detail in *Chapter 2, Digitizing Analog Signals into the Computer*.

Timing Options The Timing dialog, illustrated in Figure 5.8, is used to set Fields that determine the digitization length and method. This dialog is opened by pressing the Timing button inside the Setup dialog, and mirrors some of the settings inside the Setup dialog.

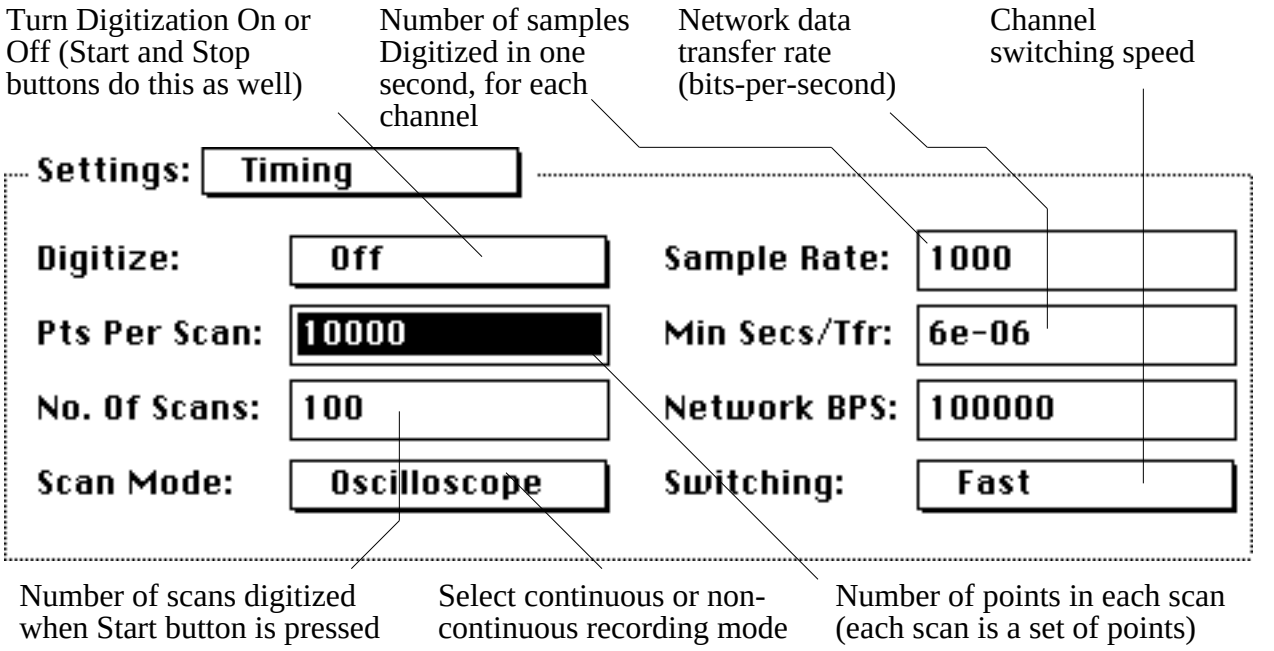

Timing...
Turn Digitization On or Off (Start and Stop buttons do this as well)
Number of samples Digitized in one second, for each channel
Network data transfer rate (bits-per-second)
Channel switching speed
Settings: Timing
Digitize: Off
Sample Rate: 1000
Pts Per Scan: 10000
Min Secs/Tfr: 6e-06
No. Of Scans: 100
Network BPS: 100000
Scan Mode: Oscilloscope
Switching: Fast
Number of scans digitized when Start button is pressed
Select continuous or non-continuous recording mode
Number of points in each scan (each scan is a set of points)

Figure 5.8 Timing Dialog

The Pts per Scan, and the No. of Scans Fields specify the number of points (4bytes per point) that are digitized for each Scan, and the number of scans that are digitized when the Start button is pressed. For example, if you digitize 100 pts/second, with 1000 points per Scan (i.e. 10sec per scan), and 10 scans, then your entire acquisition would consume 100seconds. Pressing the Stop button will halt the digitization process, independent of where it is in its cycle. The Scan Mode field was discussed in detail in the previous *Strip Chart or Oscilloscope Scan Mode* discussion.

The Sample Rate fields specifies the number of points digitized per second per channel. All channels run at this rate unless their % Sample Rate Field in their General settings area has been modified from its default value of 100%. This field enables one to run specific channels at a sample rate less than the master sample rate in the Timing dialog. For example, if the master sample rate is 1000s/sec and a channel's % Sample Rate is set to 25, then the channel will run at 250s/sec. The Network BPS specifies the network data transfer rate, in units of bits-per-second. On power up, the network is set to the fastest possible rate. The Switching popup is sets the analog channel switching to Fast or Accurate. If Fast is used, the system switches from one channel to another as fast as possible; otherwise, with Accurate,

the switching is a little slower, yet provides the amplifiers more time to settle, and is therefore a little more accurate.

Display Options

The Fields in the Display Options dialog are used to specify Display attributes, as illustrated in Figure 5.9. This dialog is opened by pressing the More button, inside the Setup Dialog, and mirrors some of the settings within the Setup dialog.

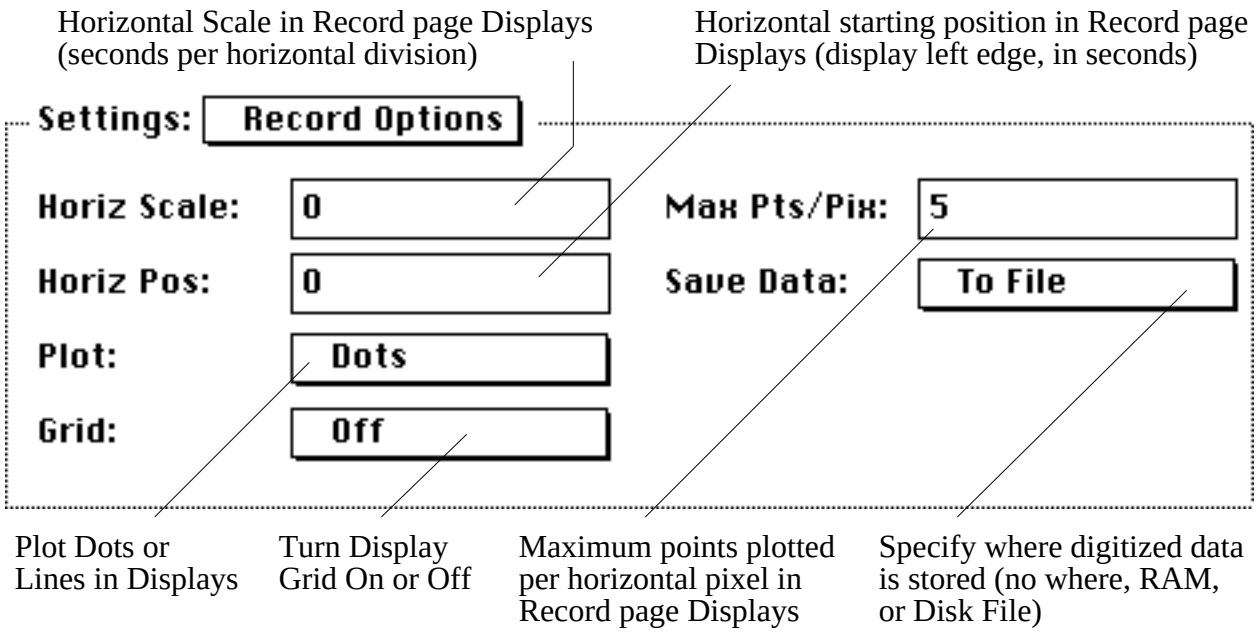


Figure 5.9 Display Options

It is in the Options dialog that one specifies to Plot Dots or Lines, to turn the Grid On or Off, to set the horizontal scale (i.e. time per horizontal division), and to set the maximum plotting density (maximum points plotted per horizontal pixel). Plotting Lines (i.e. connecting points with lines) takes more time than Dots, yet is easier to read if the points are far apart. The Grid take some time to plot as well, and might not be desirable if you are trying to maximize your update rate in Oscilloscope mode. If the horizontal scale (Horiz Scale) is too small (e.g. 10ms/div), the waveform might whip across the screen and be difficult to see in the Strip Chart mode. The maximum points per horizontal pixel (Max Pts/Pix) parameter is useful at plotting only a fraction of the digitized points in cases where you are digitizing ten's of thousands of points and don't want the computer to slow down due to plotting. The Horizontal Position (Horiz Pos) field is very similar to the Horizontal scroll bar in that it defines the time of the left edge of all displays.

Saving Data

The Digitize Into option in the Display Options dialog is used to determine whether waveform data is saved to To Ram Buffer, saved to To File, not saved (Off), or determined by the user (User Control).

Off

If the user selects Off, the waveforms are viewed while they are digitized, however you cannot scroll through them post acquisition (since the computer had not saved the data). Since this does not consume memory or disk space, one could digitize many waves at a fast rate for a long time.

To Ram Buffer If one selects To Ram Buffer, each Scan is sent to RAM memory, which is limited by the amount of RAM that has been allocated to the instruNet World application program (or the calling application program in the case of calling the instruNet driver). The buffer in memory holds only one Scan's worth of points, and therefore overwrites the previous Scan with each subsequent Scan. If you are doing Strip Chart work and don't like this, set the No. of Scans field in the Timing dialog to 1, and the Pts Per Scan field to the value required to hold the entire acquisition. If you run out of RAM memory on a Macintosh, you should consider giving your application more by selecting the Application Icon from the Finder, choosing Get Info under File, and then increasing the number in the memory "Minimum Size" field. Each point consumes 4 bytes since they are stored as 32 bit floating point numbers. For example, 100K points would consume 400KBytes. If you have just completed an acquisition with data being sent to RAM and want to save it to disk, press the Save button at the top of the Record page. This will save all waves to disk. You can then load the waves by pressing the Open button.

To File If you want to save all scans to disk, set the Digitize Into option to To File. This will cause all waves to be spooled to disk as they are acquired. If you are doing Strip Chart work, you can then use the horizontal scroll bar to scroll through the entire stream of data. To load in data that was previously saved to disk, press the Open button and then select a previously saved wave in the File Open dialog. Saving to disk is helpful if your waveforms are longer than available RAM.

User Control If User Control is selected in the Digitize Into field, then data will be saved per the settings in the User Ram Buffer, Driver Ram Buffer, and File Settings areas -- which are described later in this manual.

Trigger Options

The Trigger dialog is accessed by pressing the Trigger button within the Setup dialog. This dialog is used to specify when digitizing begins after the Start button is pressed, as illustrated in Figure 5.10.

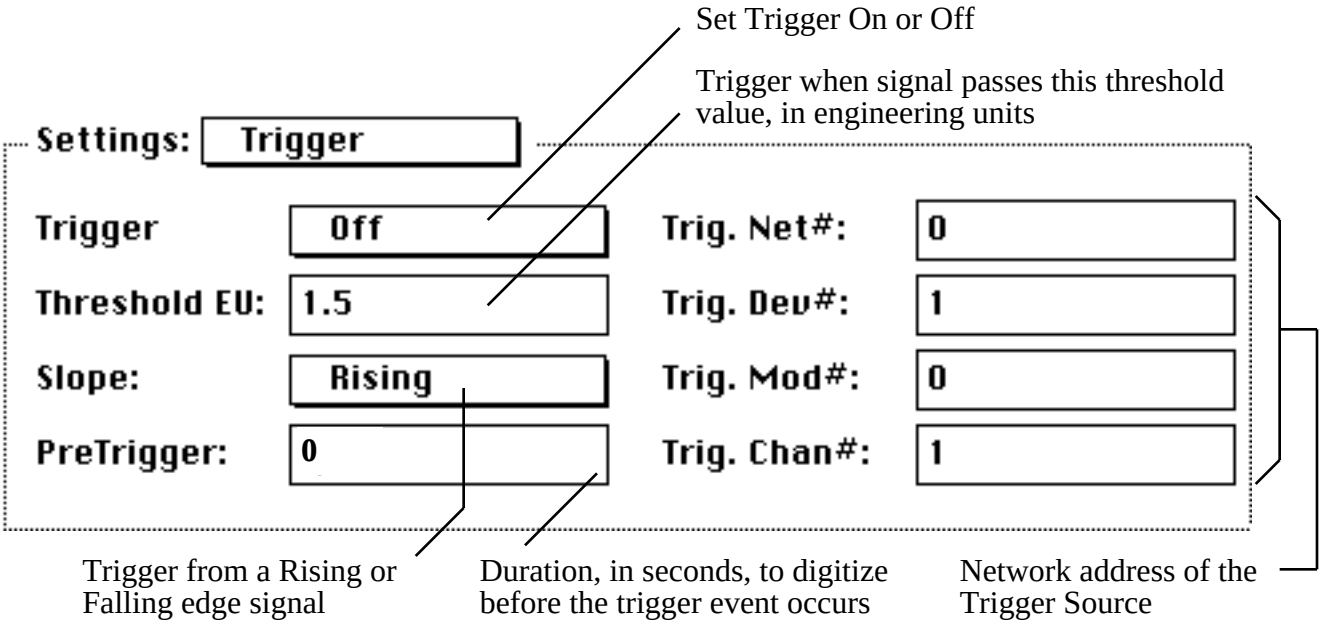


Figure 5.10 Trigger options

The Trigger field is used to specify no trigger (Off), Automatic trigger, or Normal trigger. Normal trigger will wait forever until the trigger condition is met, whereas Automatic will trigger after several seconds even if the trigger condition is not met. The Threshold EU field is used to set the threshold level, in engineering units, that the incoming signal must pass in order to trigger. The Slope field sets the trigger condition for either a low-to-high pass through the threshold (Rising), or a high-to-low (Falling). The Network number, Device number, Module number, and Channel number fields are used to specify the network address of the input channel that is to be used as the trigger source. For example, {1,1,1,1} would specify the first channel within the first module in the first device tied to the first network.

Getting Ready to Digitize

Before you digitize, you might want to view the settings in the Setup dialog box, which is opened by pressing the Setup button at the top of the Record page. This dialog's fields are described in detail in the previous pages. In summary, one must specify the number of samples digitized per second per channel (i.e. "sample rate"), the number of points per scan, the number of scans, and weather or not the scans are continuous (i.e. Oscilloscope or Strip Chart Recorder mode). The Trigger dialog is used to define when the digitizing begins (e.g. begin when the voltage at Channel #1 exceeds 3Volts). In many cases, there is no Trigger, and the digitization begins when the Start button is pressed.

Digitizing

To begin digitizing, press the **Start** button in the upper-left corner. Waveforms will plot across the screen, in real-time, as they are digitized. To stop digitizing, press the **Stop** button. If the waves had been saved to Ram or Disk (i.e. via the Digitize Into field in Options dialog), then you should be able to scroll through your data with the Horizontal scroll bar.

If Your Sample Rate Is Too Fast...

If the sample rate is too fast, an alert will appear notifying the user to a buffer overflow or sample rate problem. This means the computer and/or Controller cannot keep up with the incoming data. In this case, you have several options:

1. Reduce the master sample rate (i.e. Sample Rate field in Setup dialog), or the number of digitized channels.
2. Decrease the % Sample Rate field in a Channel's General settings area to decrease the sample rate for that specific channel. For example, if you run 1 channel at 10% of the master sample rate, then its sample rate will be 1/10 of that of the other channels.
3. Decrease the amount of plotting by reducing the size of the instruNet World window, plotting Dots instead of Lines (i.e. set the Plots field to Dots in the Options dialog), or reducing the plotting density by decrease the Max Pts/Pix field in the Options dialog.
4. Reduce the amount of digital filtering in the Low Pass, High Pass, Band Pass and Band Stop settings areas. Digital filters consume several microseconds to .1us per Filter Order, per point digitized.

Record Buttons The Record Page sports the following buttons:

Start Start digitizing channels that have been turned On. Each channel is viewed in its own display. The Digitize Into field in the Setup Dialog determines whether data is saved to RAM or Disk.

Stop Stop digitizing. If the data had been saved to Ram, then one can now scroll through the most recent Scan, or save the Scan to disk by pressing the Save button. If the data had been saved to Disk in Strip Chart mode, the user can now scroll through the entire set of Scans via the horizontal scroll bar.

Open The Open button loads waveforms to disk that had been previously saved to disk during acquisition, or by the Save button after acquisition had completed. The standard File Open dialog is used to select the specific wave file. Since waves are saved in their own file, in one directory, it is necessary to only select one file, in order to load the entire set. Once loaded, one can use the horizontal scroll bar to scroll through them.

Save Saves to disk the current Scan in RAM memory. The user is prompted for a directory name in which to save the set of data, where each wave is saved in its own file, in one common directory. The data is saved in the fast instruNet Binary Merge format, multi-file Binary format, or slow generic TEXT format as determined by the File Type field in the Digitizer Channel, within the Driver . If Text Merge is selected in the File Type popup, an additional "Merged.txt" text file is saved that contains all waves in one file, one column of text per wave. This is useful when transferring data to a spreadsheet. Binary Merge saves to disk faster than Binary, yet consumes more RAM memory.

Setup Opens the Record Setup dialog, as described in the previous pages.

Test Page

The Test Page, illustrated in Figure 5.12, is used to determine what instruNet hardware is attached to your computer, and to test all instruNet hardware and software. After each test, a report is printed to a miniature text editor within the Test Page. The user can then type notes into this window and save them to disk as a TEXT file, to later be opened with the Open button in the Test Page, or a word processor. The Test Page supports the standard text Cut, Copy, and Paste commands, in addition to typing. To select the Test Page, press the Test tab at the base of the instruNet World window.

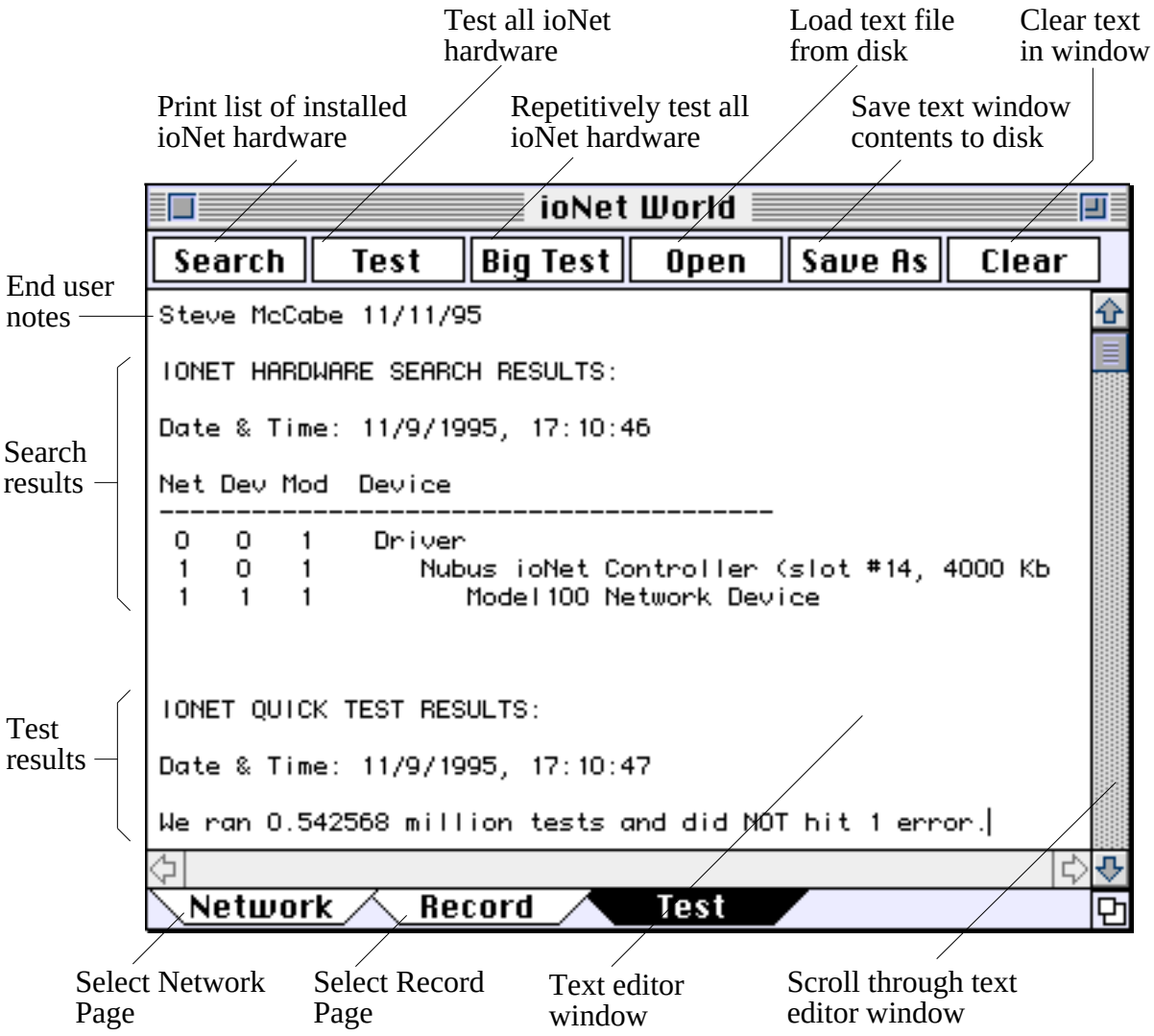


Figure 5.12 instruNet World Test Page

Test Buttons

The Test page sports the following buttons:

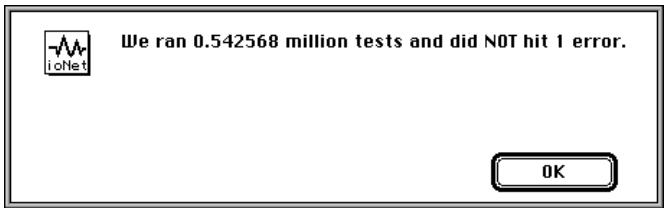
Search

Generates a report, similar to that below, that lists all instruNet hardware attached to your computer. This includes all Controllers and all Devices. If this report disagrees with what you think is out there, please check your cables and consult the "Verify That Your System Is Working Properly" discussion in *Chapter 1*.

```
INSTRUNET HARDWARE SEARCH RESULTS:
Date & Time: 10/23/1995, 19:23:20
Net Dev Mod  Device
---------------------------------------
 0   0   0  Mac OS Ver 8.0.0
 0   0   1    instruNet Driver Version 1.24
 0   0   1    instruNet BASIC license 32-048353-62581
 1   0   1       Nubus Controller #iNet-220 (slot #13, 2666KBD, 7us, 95%)
 1   1   1           Device #iNet-100 (SN37526, Cal 8/27/1997, Rev 3, 27.52C, 7us, 4mA)
```

Test

Click the Test button to test all Controllers, Devices, Modules, Channels, and software. This test requires less than a minute and when done displays an alert similar to that shown to the right. A report similar to that shown below is also printed to the Test Page's TEXT window. For a list of the error codes please consult *Appendix II instruNet Error Codes.* For tips on trouble shooting, please consult *Appendix I*.




```
INSTRUNET QUICK TEST RESULTS:
Date & Time: 11/8/1995, 17:17: 1
We ran 0.542568 million tests and did NOT hit 1 error.
```

Big Test

Big Test is identical to Test except it runs continuously until you press the mouse button down and hold it down until the test stops. It will run all night if you let it. This is helpful at identifying intermittent problems that occur once in a blue moon.

Open

Opens a TEXT file and displays its contents in the Test Page's mini-text editor.

Save As

Saves the contents of the Test Page's mini-text editor to disk in a TEXT file.

Clear

Discards the text in the Test Page's mini-text editor.

The BASIC Page

The BASIC page contains a text editor that is used to develop, test, save, and view instruNet BASIC Code. This language is designed to help users automate the set up of instruNet channels, calibration, and data taking. This language is described in detail in *Chapter 9, instruNet BASIC*; and for a tutorial, please refer to *Chapter 2, Automate Setup and Data Taking with instruNet BASIC*. The BASIC page buttons are described as follows:

If text is selected in the BASIC page, this text is executed as instruNet BASIC code; otherwise, the entire contents of the BASIC page is executed.

Stops execution of all instruNet BASIC code.

Opens a TEXT file and displays its contents in the BASIC Page text editor.

Saves the contents of the BASIC Page in the last saved or loaded TEXT file. If one does not exist, the Save Dialog prompts the user for a file name and location.

Saves the contents of the BASIC Page to disk in a TEXT file.

Discards the text in the BASIC Page.

6 Hardware Reference

This chapter includes specifications for the following instruNet hardware products:

instruNet Controllers
- Model 200(s) instruNet Controller for Win95/NT PCI bus or Macintosh/PCI bus
- Model 220(s) instruNet Controller for Macintosh Nubus bus
- Model 230(s) instruNet Controller for Win95 PC-Card bus (16bit PCMCIA)

instruNet Network Devices
- Model 100, 100B, and 100HC Analog/Digital I/O Network Device

instruNet Network Accessories
- Model 300 Power Adaptor
- Model 311 and 322 Power Supplies
- Model 330 Electrical Isolator

Model 200 PCI and 220 Nubus instruNet Controllers

The Model 200(s) and 220(s) instruNet Controller boards attach to personal computers via an expansion slot to drive an instruNet network, and to provide several Digital Timer I/O channels at a 34-pin connector, as illustrated in Figure 6.1a. Table 6.1 describes the pins at the Controller 34-pin connector.

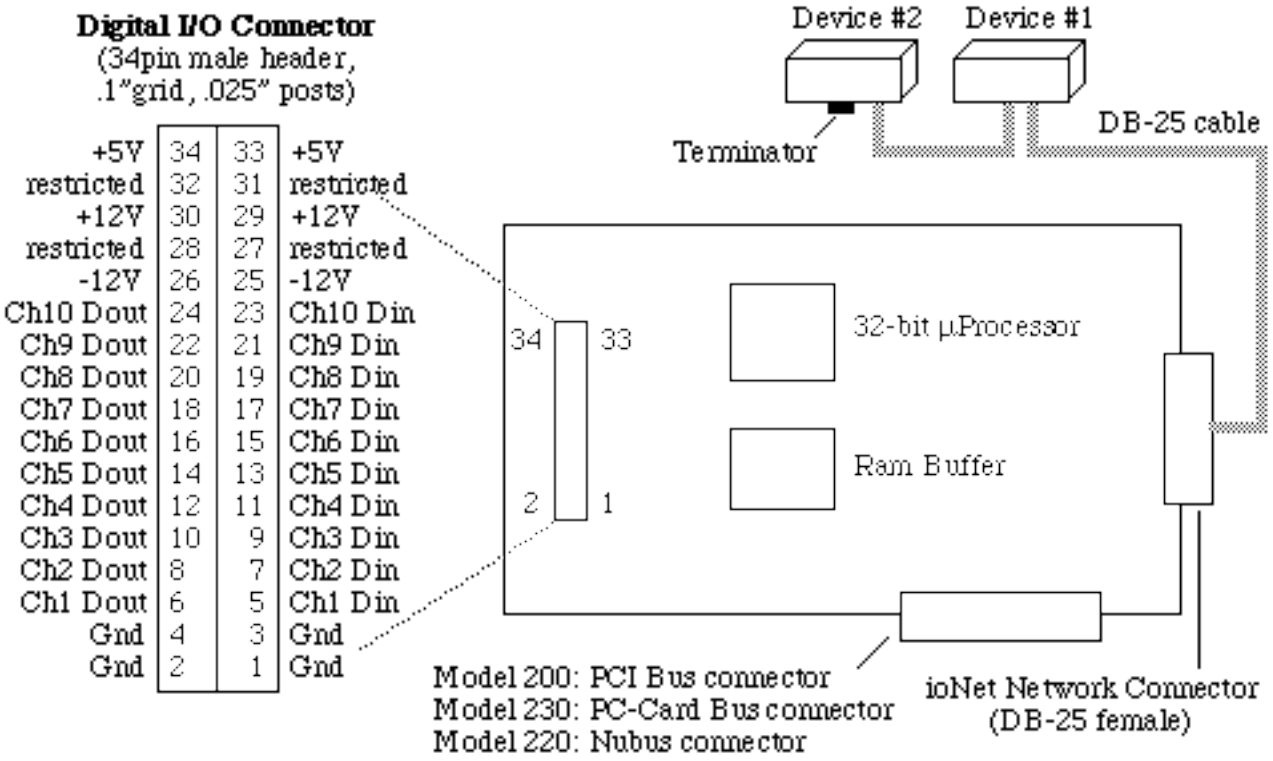


Fig 6.1a Model 200 and 220 instruNet Controller Connector Layouts.

Specifications

The physical specifications for the Model 200 and 220 Controllers are as follows:

Digital I/O Connector:	34-pin male ribbon connector*
Network Connector:	DB-25 female connector
Network Data Throughput:	100Kbits/sec to 4,000Kbits/sec
Dimensions:	4" x 7"
Operating Temperature Range:	0 to 70˚C
Storage Temperature Range:	-25 to +85˚C
Relative Humidity:	Up to 90% (non-condensing)
Power Consumption:	+5V @ 1A max
(does not include network)	+12V @ 10mA max
	-12V @ 10mA max

Controller 34-pin Connector I/O Terminals	**Specifications** (typical at 25°C)	
Ch1..10 Din The {Ch1 Din...Ch10 Din} digital input terminals are used to sense a digital high or digital low state; or to measure the period of a changing digital signal. The inputs are protected against high voltages up to +6Volts and down to -6V. To measure the logic level or the period of an input signal, connect it directly to a Controller Din terminal and then connect the signal source ground to a Controller Gnd terminal. For details, please see *Ch2, Working with Controller Digital Timer I/O Channels.*	**Digital Inputs**	
	Digital Input Port	1 non-latching input bit per channel
	Input Levels	V_{IH} = 3.5V min ... 6V max V_{IL} = .75V max ... -6V min I_{IH} = -120µA, V_i = 3.5V I_{IL} = -.6mA max. $V_{HYSTERESIS}$ = .5V
	Period Measurement	
	Measured Period Range	3us to 16ms with ±.25us accuracy, or 12ms to 576sec with ±4ms accuracy
	Resolution	65536 (16-bit)
Ch1..10 Dout The {Ch1 Dout...Ch10 Dout} digital output terminals can be set to a high or low state; or set up to output a digital clock signal. To wire a Dout terminal to a device, connect the Dout terminal to the device input, and the Controller Gnd terminal to the device Ground. For details, please see *Ch2, Working with Controller Digital Timer I/O Channels.*	**Digital Outputs**	
	Digital Output Port	1 latching output bit per channel
	Logic	TTL-compatible
	Output Levels	V_{OH} = 2V min ... 5V max V_{OL} = 0.5V max ... 0V min I_{OH} = -12mA max. I_{OL} = 24mA max.
	Clock Outputs	
	Duty Cycle Range	.01% to 100%
	Period Range	5µsec to 536 sec (programmable)
	Time Base Accuracy	+- 0.01%
	Output Signal	TTL Compatible
+5V, -12V, +12V These terminals can be used to power external devices. **The maximum allowed current, listed to the right, must not be exceeded; otherwise damage might occur to the Controller or computer.** To power an external device, one must attach a wire from one of the Controller power terminals to the external device's power input, and also attach a wire from the Controller's Gnd terminal to the external device ground.	**Power Available to User**	
	+5V	300 mA max.
	+12V	50 mA max.
	-12V	50 mA max.

Table 6.1 Model 200 and 220 Controller 34-pin Connector Technical Specifications .

*The Model 230 PC-Card Controller does not include the 34-Pin Digital I/O Connectors, and its signals.

Model 230 PC-Card instruNet Controller

The Model 230(s) PC-Card (16bit PCMCIA) instruNet Controller attaches to a personal computer via a 16bit PC-Card slot to drive an instruNet network, as illustrated in Figure 6.2.

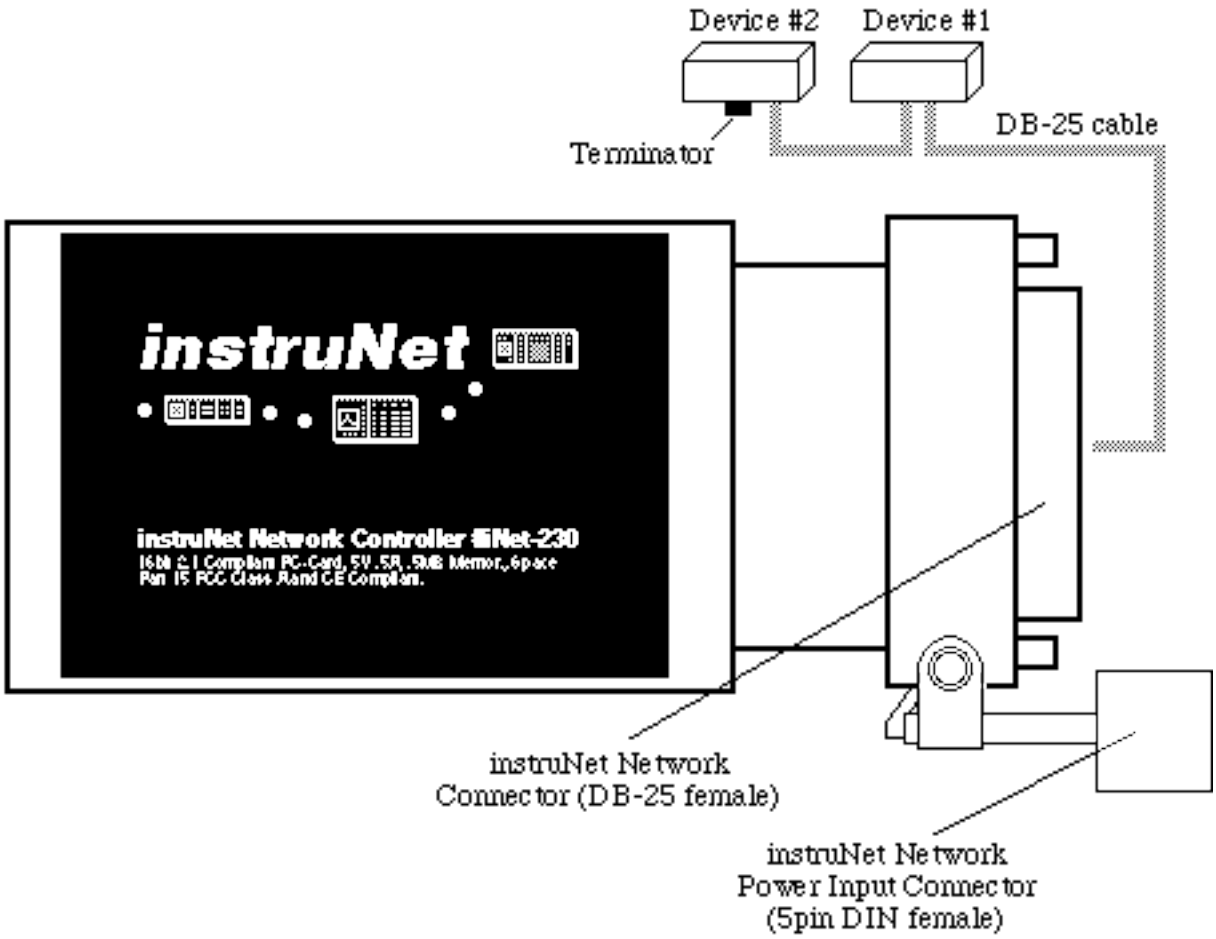


Fig 6.1b Model 230 instruNet Controller .

Specifications

The physical specifications for the Model 230 Controller is as follows:

Network Connector:	DB-25 female connector
Network Power Input Connector:	5pin DIN female connector
Network Data Throughput:	100Kbits/sec to 4,000Kbits/sec
Dimensions:	2.1" x 3.4"
Operating Temperature Range:	0 to 70˚C
Storage Temperature Range:	-25 to +85˚C
Relative Humidity:	Up to 90% (non-condensing)
Power Consumption:	+5V @ .5A max

Model 100, 100B, and 100HC Network Devices

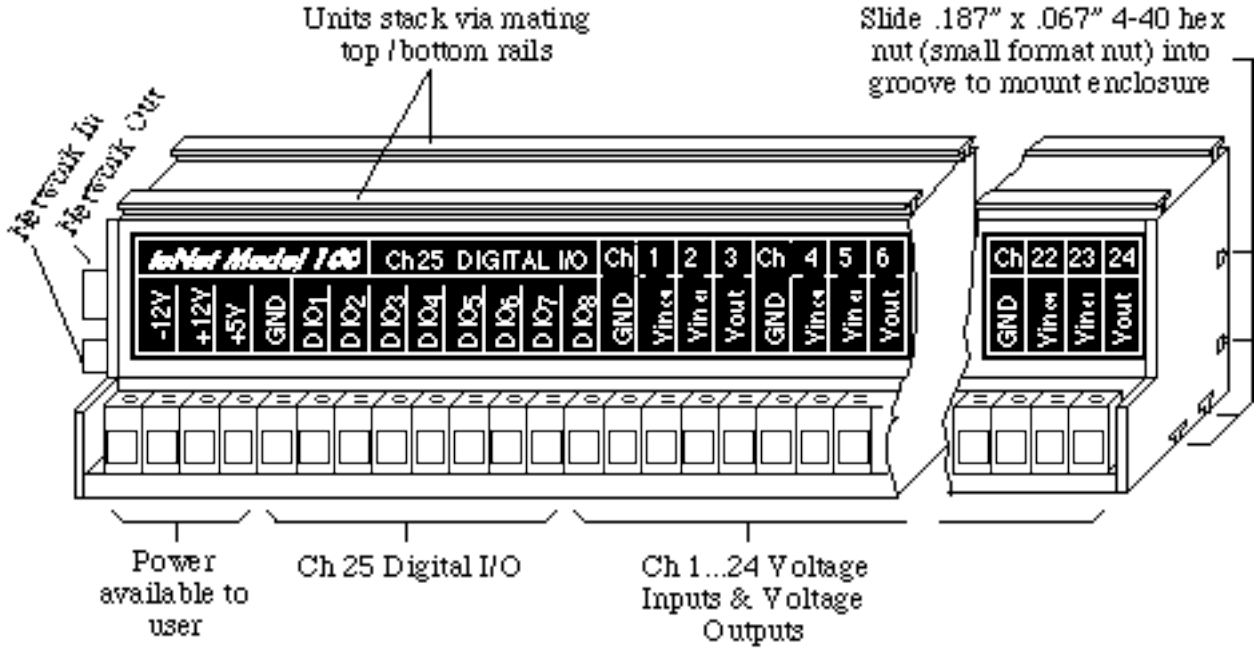

Units stack via mating top / bottom rails
Slide .187" x .067" 4-40 hex nut (small format nut) into groove to mount enclosure
Power available to user
Ch 25 Digital I/O
Ch 1...24 Voltage Inputs & Voltage Outputs

Fig 6.2 Model 100xx Network Device Connector Layout.

Model 100xx Connector I/O Terminals	Specifications[1]	
Ch 25 Digital I/O This is a digital I/O port consisting of 8 individual lines, each of which can be configured as either a digital input channel or a digital output channel. When configured as an input, a channel can be used to sense a digital high (3.2V to 10Volts) or digital low (0 to 1Volts). When configured as an output a channel can be set high (2.0V min) or low (.5V max). The inputs are protected against high voltages up to and +12Volts and down to -12V.	**Digital I/O**	
	Digital Input/Output	8 non-latching input bits and 8 latching output bits at 8 bidirectional screw terminals
	Input Levels	V_{IH} = 3.2V min ... 12V max V_{IL} = 1.0V max ... -12V min I_{IH} = -200µA, V_i = 3.2V I_{IL} = -.5mA max.
	Output Levels	V_{OH} = 2V min ... 5V max I_{OH} = -.5mA max. I_{OL} = 500mA max, V_O=1.7V I_{OL} = 50mA max, V_O = .7V

Table 6.2 Model 100, 100B, and 100HC Technical Specificati

Model 100xx Connector I/O Terminals	Specifications[1]

Ch 1...24 Vin+/Vin-

These are voltage input ports that can be wired for any of the sensors described in Chapter 5 Sensor Reference. When wiring single-ended inputs the Vin+ and Vin- terminals function identically.

Analog Inputs

A/D Conversion Time	4µs min
A/D Resolution	14-bit
A/D Ranges	+- 5V, +-.6V, +- 78mV, +- 8mV
Amplifier Gain	1, 8, 64, 512
Number of Channels	16se/8di
System Throughput	166Ksamples/second max

Measurement Accuracy

Voltage Range	Integration (seconds)	Channel Switching	Voltage Accuracy
±5V	1ms	(either)	±.7mV
	0sec	Accurate	±1.5mV
	0sec	Fast	±2.5mV
±.6V	1ms	(either)	±75µV
	0sec	Accurate	±150µV
	0sec	Fast	±225µV
±80mV	1ms	(either)	±15µV
	0sec	Accurate	±45µV
	0sec	Fast	±60µV
±10mV	1ms	(either)	±10µV
	0sec	Accurate	±30uV
	0sec	Fast	±50µV

Signal To Noise Ratio	78dB
Differential Linearity	+- 1.5 LSB
Integral Linearity	+- 2 LSB
Input Over voltage Protection	+- 15 V (power on or off)
Input Impedance	10MΩ ±1%, 3pf
Common Mode Voltage (CMV)	+- 5V min.
Common Mode Rejection (CMR)	+- 80dB
Temperature Drift	Gain: +- 5ppm/˚C of FSR Offset: Self-cal'ed to 0
Time Stability	Gain: 27ppm/1yr typ Offset: Self-cal'ed to 0

Ch 1...24 Vout

These are voltage output ports that can be used for purposes such as stimuli and sensor excitation.

Analog Outputs

D/A Resolution	8-bit
Number of Channels	8
Output Voltage Range	#100/100B: ±5V, 4mA,.001uF #100HC: ±5V, 15mA, .01uF
Output Protection	Short-to-ground continuous
Output Settling Time	4µs (to +-1/2 LSB,+-5V step)
Analog Output Accuracy	+-0.4%
Digital Coupling	+-20mV
Gain Drift	+- 10ppm/˚C of 5V FSR
Offset Drift	+- 5µV/˚C

Table 6.2 Model 100, 100B, and 100HC Technical Specifications.

Model 100xx Connector I/O Terminals	Specifications[1]	
+5V, +12V, -12V These screw terminals can be used to power external devices. The maximum allowed current specified in the table to the right should not be exceeded, else the controller and/or the computer could be damaged. To power an external device, run a wire from a voltage output terminal (e.g. "+5V) to the device and also run a wire from one of the ground terminals (i.e. "GND") to the device ground.	+5V +12V -12V	100 mA max. 30 mA max. 30 mA max.
Network Interface The Model 100 cables to a Controller and/or other Network Devices via DB-25 cables.	Network Utilization: Compatibility: Network Connector:	Occupies 1 physical address in instruNet Network All instruNet Controllers and Network Devices DB-25 male connector (input), DB-25 female connector (out)
Physical/Environmental All I/O signals cable to the Model 100 via screw terminals.	I/O Connector: Dimensions: Operating Temperature Storage Temperature Relative Humidity:	Screw Terminals 1.8" x 4.2" x 9" 0 to 70˚C -25 to +85˚C Up to 90% (non-condensing)
Power Power consumed by the Model 100 Network Device without additional Network Devices attached, without a terminator, and without outputs loaded. Total system power consumption is the sum of the power consumed by the Controller and each attached Network Device.	Power Consumption:	+5V @ 180mA max +12V @ 80mA max -12V @ 80mA max

Table 6.2 Model 100, 100B, and 100HC Technical Specifications.

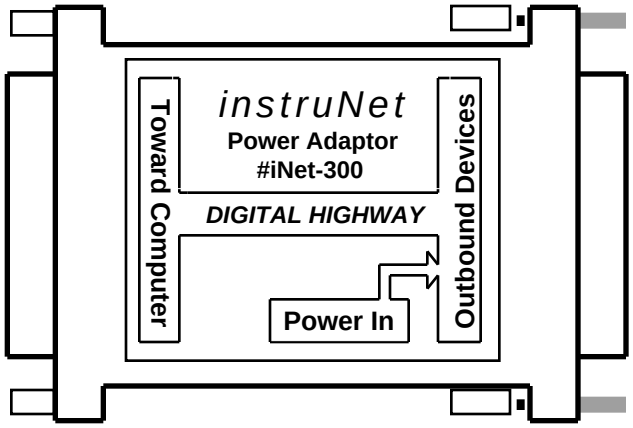
[1]Measurement Accuracy

0-70°C, no condensation, #iNet-100xx Rev 3, temperature has not changed since self-calibration, Accuracies are typical within 2 standard deviations.

Accuracy is effected by the Channel Switching field (i.e. set in the Setup dialog to Accurate or Fast) and the integration time. If the Channel Switching field is set to Accurate, the signal is given more time to settle after the channel multiplexor is switched. Accurate switching has a lower maximum sample rate than Fast switching.

Integration time is independently programmable for each channel, and reduces noise by averaging many samples. Also, if more than 125 samples are averaged, a dithering noise generator automatically turns on to add noise to the input signal. This increases the accuracy further by using more a/d codes to establish the input voltage.

Model 300 Power Adaptor



instruNet controllers provide power to external devices; however this power is sometimes inadequate due to too many devices on the network, or a network length that induces an unacceptable voltage drop between the controller and the devices. Subsequently, one can insert a Model 300 Power Adaptor inline the instruNet network, preferably close to the Devices receiving power, and connect an external power source (e.g. #iNet-311 or 322 Power Supply) to the Model 300 External Power Source input connector. Multiple Model 300's can be placed in one network (e.g. place one Model 300 every 4 Devices, in a 16 Device network).

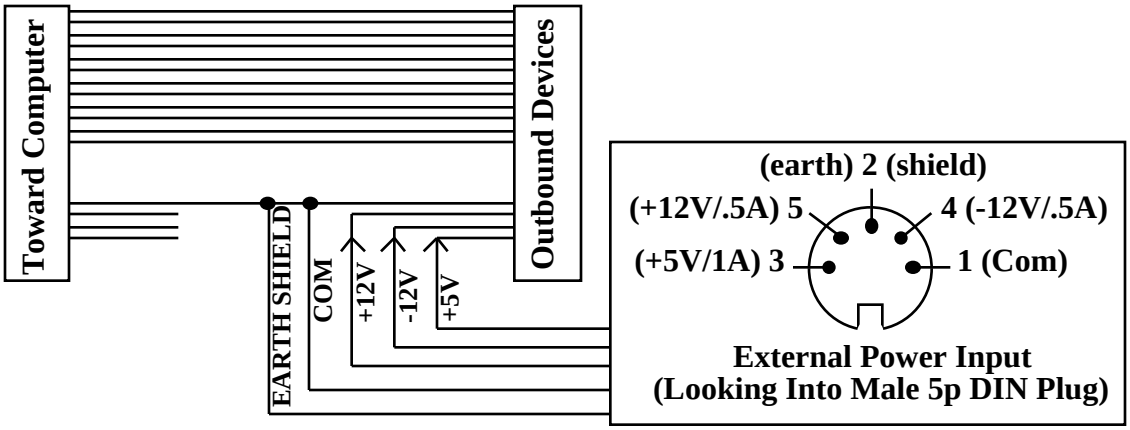


Fig 6.3 Model 300 Power Adaptor Block Diagram

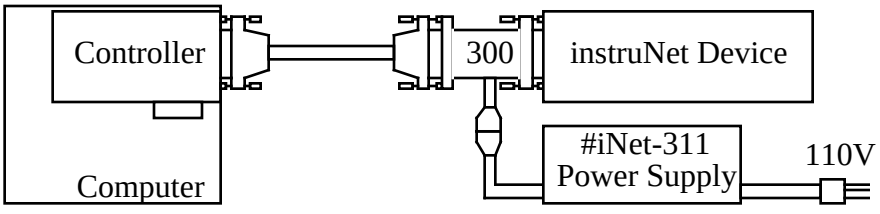


Fig 6.4 Example Application of Model 300 Power Adaptor

Model 311 and 322 Power Supplies

The following power supplies provide a 5pin Din output connnector compatible with the instruNet #iNet-300 Power Adaptor, #iNet-330 Electrical Isolator, and #iNet-230 PC-Card. The 5pin DIN connector pinout is as follows: 1: Com, 2: n/c or earth gnd, 3: +5V, 4: -12V, 5: +12V.

Part #	Plug	Input	Output
#iNet-311	USA 3-Prong	120VAC	5V/.7A, +-12V/.24A
#iNet-322	Euro 2-Prong	220VAC	5V/2A, +-12V/.5A

Linear power supplies are strongly recommended over switchers, since switchers tend to have a spike on their COM output with respect to earth Ground, and this typically creates a problem when doing low level measurements.

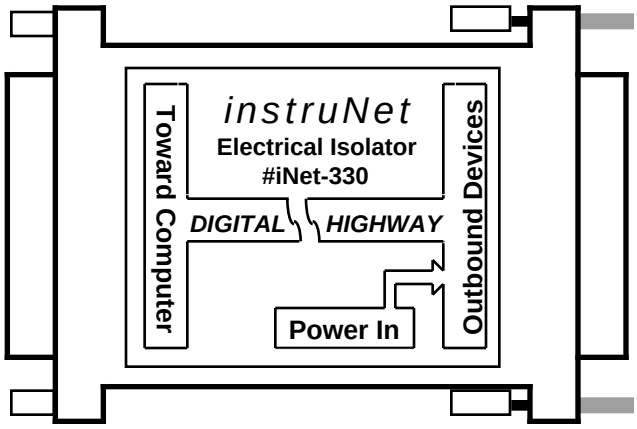
Power Plugs

iNet-311 110VAC External Power Supply
This includes a USA 3 prong plug and has a 110VAC input. This mates with USA wall sockets. Connecting to Sockets in Japan requires removing this plug and adding a Japaneese plug. Japan is 110VAC.

iNet-322 220VAC External Power Supply
This unit includes a European 2 prong euro plug with a receptical for the earth pin. It mates with wall sockets in Germany, France, Italy, Spain (yet not UK).

If the power plug does not match your wall socket...
If the power plug doesn't fit, we recommend that it be removed and replaced with one that does.

Model 330 Electrical Isolator



The Model 330 Electrical Isolator provides 1000 Volts of optical isolation at one point within an instruNet network. This is often used to eliminate ground loops between the computer and items under test, and to reduce noise that is transmitted from the computer to sensors. When measuring small voltages (e.g. <10mV), optical isolation is sometimes critically important. The Model 330 Electrical Isolator is very similar to the Model 300 Power Adaptor, described earlier, except for its isolation capability. An external power source (e.g. #iNet-311) must be connected to the 5pin DIN Power Source Connector, to provide power to outbound devices. Multiple Model 330's can be placed in one network (e.g. place one Model 330 every 4 Devices, in a 16 Device network).

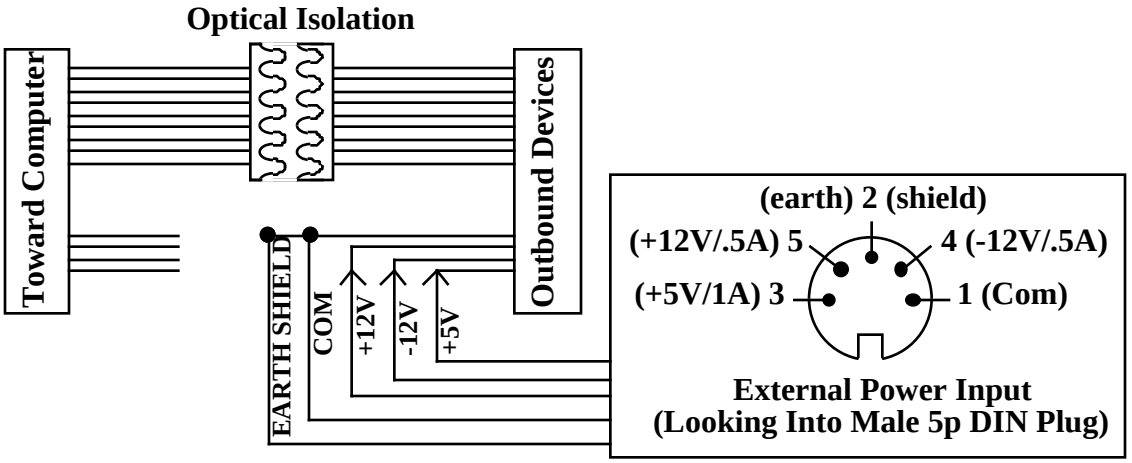


Fig 6.5 Model 330 Electrical Isolator Block Diagram

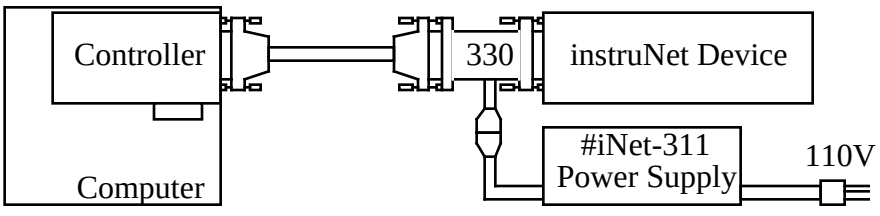


Fig 6.6 Example Application of Model 330 Electrical Isolator

Isolating From Earth Ground

The External Power Input pins 1 and 2 are both tied to the outbound instruNet device ground (case and pcb). If this is also tied to the 3rd prong of the power supply AC input connector, and you want to isolate instruNet from this earth ground, then you would need to place a 2-to-3 prong Adaptor at the power supply input connector (or rip the 3rd prong out of the plug with a pair of strong pliers).

Wild Grounds

If the outbound devices are not seen by instruNet World, try temporarily holding a wire between the outer shell of the isolator inbound and outbound DB-25 connectors. If the outbound devices are then seen by instruNet World (after Reset), then this indicates that a very high frequency exists between the two grounds and is causing problems. The Model 330 is designed to sustain a signal between the two grounds that is 50V peak-to-peak with a 1000V/us slew rate (e.g. slews 1Volt in 1ns); and this is adequate is most applications.

Slower Speeds

Since the optical isolators introduce delays, the Model 330 reduces the speed of the instruNet network from 4M bits/sec to 1.33M bits/sec, on short networks. In a worse case scenario, this would reduce the maximum sample rate 3 to 1.

7 Channel Reference

The following table summarizes the Channels provided by each instruNet hardware Device, the Settings offered by each channel, and the Fields within each Settings group.

Hardware Device	Channel	Setting Group	Fields
Model 200 PCI, Model 220 Nubus, Model 230 PC-Card Controllers	Ch1…10 Digital Timer I/O	General	Value I/O, Units Label, User Name % Sample Rate
		Display	Display On/Off, Display Max EU, Display Min EU
		Timer	Function, Clk Period, Clk Out Hi, Measure, Meas. Resol., Meas. Cycles
	Ch 11 Time	General	Time Secs, Units Label, User Name % Sample Rate
		Display	On/Off, Max EU, Min EU
	Ch 12 Digitizer	General	Value, Units Label, User Name, % Sample Rate
		Timebase	Digitize Off/On, Pts Per Scan, No. Of Scans, Min sec/tsfr, Sample Rate, Scan Mode, Switching, Network BPS
		Trigger	Trigger Off/On, Threshold EU, Slope, Trig. Net#, Trig. Dev# Trig. Mod#, Trig. Chan#

Continued...

Table 7.1 Channel Reference.

Hardware Device	Channel	Setting Group	Fields
Model 100 Analog & Digital I/O System	Ch1 Vin+, Ch2 Vin-, Ch4 Vin+, Ch5 Vin-, Ch7 Vin+, Ch8 Vin-, Ch10 Vin+, Ch11 Vin-, Ch13 Vin+, Ch14 Vin-, Ch16 Vin+, Ch17 Vin-, Ch19 Vin+, Ch20 Vin-, Ch22 Vin+, Ch23 Vin-	General	Value Input, Units Label, User Name % Sample Rate
		Hardware	Sensor, Wiring, Low Pass, Integrate Range
		Constants	Ro, Rshunt, Vout, Vinit, alpha delta/Rlead, GF, υ _Poisson
		Display	Display On/Off, Disp Max EU, Display Min EU
		Lowpass Filter	Filter type, PassB Ripple, StopB Attn Filter Order, PassB F1 Hz, StopB F1 Hz
		Highpass Filter	Filter type, PassB Ripple, StopB Attn Filter Order, PassB F1 Hz, StopB F1 Hz
		Bandpass Filter	Filter type, PassB Ripple, StopB Attn Filter Order, PassB F1 Hz, StopB F1 Hz, PassB F2 Hz, StopB F2 Hz
		Bandstop Filter	Filter type, PassB Ripple, StopB Attn Filter Order, PassB F1 Hz, StopB F1 Hz, PassB F2 Hz, StopB F2 Hz
		File	File, Digitize, File Name, Command Scan Num, 1st Pt Num, Num Pts
		Driver Ram	Digitize On/Off, Buffer Addr, Ptr Byte Size, Scan Num In, Pt Num In, Scan Num Out, Pt Num Out
		User Ram	Digitize On/Off, User Ptr, Ptr Bytes Size, Scan Num In, Pt Num In, Scan Num Out, Pt Num Out
	Ch3, Ch6, Ch9, Ch12, Ch15, Ch18, Ch21, Ch24 Vout	General	Value Output, Units Label, User Name, % Sample Rate
		Display	Display On/Off, Disp Max EU, Display Min EU
	Ch25 DIO	General	Value Output, Units Label, User Name, % Sample Rate
		Display	Display On/Off, Disp Max EU, Display Min EU
		Hardware	Digital Out, Direction

Table 7.1 Channel Reference.

8 Settings Reference

This chapter summarizes the Settings field groups used by the instruNet field hierarchy. Each group may be used many times; for example, the Display group contains 3 fields (Display On/Off, Disp Max EU, and Display Min EU) and is used with 25 Channels in the Model 100 hardware device. Each Settings group contains 1 to 8 fields, as described in the following table. And each field can be set to a different value, as described in this table.

For Programmers:
Each Setting Group has an associated settingType value, which are passed to the iNet() subroutine in the 'settingGroupNumOrType' argument. These are listed in the 1st column of the table in subscript form. For example, the settingType of the Filter Settings group is -11. These are also listed in the ion_settingGroupType area of the interface .h file.

Each Field has an associated fieldNum value, which are be passed to the iNet() subroutine in the 'fieldNum' argument. These is listed in the 2nd column of the table in subscript form. For example, the fieldNum of the PassB Ripple field within the Filter Settings group is 2. These are also listed in the fldnum_.... areas of the interface .h file.

Some Fields have several possible values which are passed to the iNet() subroutine in the 'ptrToArg' argument. These are listed in the 3rd column of the table in subscript form. For example, the fieldValue for the Elliptic option of the Filter field within the Filter Settings group is 2. These are also listed in the fldnum_.... areas of the interface .h file.

Settings Group settingType	**Field** fieldNum	**Field Description** fieldValue
Bandpass Filter -10		Defines a digital bandpass filter. For more information, please refer to *Chapter 2, Working with Digital Filters*.
	Filter$_1$	Selects filter model = {Off$_1$, Elliptic$_2$, Chebyshev P$_3$, Chebyshev S$_4$, or Butterworth$_5$ }.
	PassB Ripple$_2$	Specifies maximum allowable passband ripple, in dB.
	StopB Attn$_3$	Specifies the minimum stop band attenuation, in dB.
	Filter Order$_4$	Displays filter order. Automatically determined by the filter design, which is based on the specified criteria.
	PassB F1 Hz$_5$	Specifies lower cutoff frequency of the band that is passed. Frequencies between PassB F1 Hz$_5$ and PassB F2 Hz$_7$ are passed.
	StopB F1 Hz$_6$	Frequencies below StopB F1 Hz$_6$ are attenuated.
	Pass B F2 Hz$_7$	Specifies high cutoff frequency of the band that is passed. Frequencies between PassB F1 Hz$_5$ and PassB F2$_7$ Hz are passed.
	Stop B F2 Hz$_8$	Frequencies above StopB F2 Hz$_8$ are attenuated.
Bandstop Filter -11		Defines a digital bandstop filter. For more information, please refer to *Chapter 2, Working with Digital Filters*.
	Filter$_1$	Selects filter model = {Off$_1$, Elliptic$_2$, Chebyshev P$_3$, Chebyshev S$_4$, or Butterworth$_5$ }.
	PassB Ripple$_2$	Specifies maximum allowable passband ripple, in dB.
	StopB Attn$_3$	Specifies the minimum stop band attenuation, in dB.
	Filter Order$_4$	Displays filter order. Automatically determined by the filter design, which is based on the specified criteria.
	PassB F1 Hz$_5$	Frequencies below PassB F1 Hz$_5$ are passed.
	StopB F1 Hz$_6$	Specifies lower cutoff frequency of the band that is stopped. Frequencies between StopB F1 Hz$_6$ and Stop B F2 Hz$_8$ are stopped (i.e. attenuated).
	Pass B F2 Hz$_7$	Frequencies above PassB F2 Hz$_7$ are passed.
	Stop B F2 Hz$_8$	Specifies higher cutoff frequency of the band that is stopped. Frequencies between StopB F1 Hz$_6$ and Stop B F2 Hz$_8$ are stopped (i.e. attenuated).

Table 8.1 Channel Setting Group Reference

Settings Group settingType	**Field** fieldNum	**Field Description** fieldValue
Constants -4		Defines constants used to calculate engineering units when measuring sensors (e.g. RTD, strain gage, etc). For more information, please refer to *Chapter 3, Connecting To Sensors.*
	Ro_1	Specifies value of bridge completion resistor, unstrained strain gage, or resistance of an RTD at 0°C. Units are ohms.
	$Rshunt_2$	Specifies value of shunt resistor in voltage divider or current measurement circuit. Units are ohms.
	$Vout_3$	Sets excitation voltage in bridge/voltage divider circuits. Units are Volts.
	$Vinit_4$	Specifies voltage across unstrained bridge. Used for bridge calibration
	$alpha_5$	Specifies temperature coefficient of an RTD at 0°C (typically .00385 for American RTD's, and .00392 for European RTD's). This constant is specified by the manufacturer of the RTD. Units are ohms/ohms/C.
	delta, $Rlead_6$	When connecting to an RTD, delta is the Callendar-Van Dusen delta constant (typically 1.492). This constant is specified by the manufacturer of the RTD. When doing measurements using quarter-bridge and half-bridge circuits, Rlead specifies the lead resistance of the wires connecting the sensor (i.e. strain gage) to the bridge.
	GF_7	Specifies the gage factor of a strain gage. This constant is specified by the manufacturer of the strain gage, and relates resistance change to strain.
	υ_$Poisson_8$	Specifies Poisson's ratio in axial strain gage measurements.
Directory -19		Contains fields that specify where and how information is saved to, and retrieved from, disk. For the most part, this is only used by programmers. For more information, please refer to Chapter *4, Programming*.
	Path $Name_1$	Specifies the path name for the directory/folder that is used when loading or saving files via the Save or Open buttons in the Record page.
	New $Name_2$	When the Save button is pressed in the Record page to save waveforms to disk, a new directory/folder is created for the new files. If the New Name field is set to Prompt $User_1$, the user is prompted for the new folder's name and location, otherwise, if New Name is set to Auto $Generate_2$, the folder is automatically created and named.
	Save $Fields_3$	When the Save button is pressed in the Record page to save waves to disk, the user has the option of saving the network Fields with the waveforms. Save Fields is set to On_1 if Fields are to be saved, and Off_2 if they are not.
	Load $Fields_4$	If Load $Fields_4$ is set to On_1, the network Fields are loaded from disk when one presses the Open button in the Record page = {On_1, or Off_2}.
	File $Type_5$	Specifies the file type for waveforms saved to disk via the Save button in the Record page = { $Binary_1$, Text $(ASCII)_2$, Text Merge $(ASCII)_3$, Binary $Merge_4$,}. Binary and Binary Merge are fast and compact, whereas Text is compatible with other programs such as word processors and spreadsheets. Text Merge saves an additional "Merged.txt" text file that contains all waves in one file. Binary Merge saves all channels in 1 file and spools to disk very fast; whereas Binary saves each channel in its own file and uses less RAM memory.
	$Command_6$	Writing New $Directory_1$ to the $Command_6$ field causes a new directory/folder to be created. Writing Show $Dialog_2$ to the $Command_6$ field causes the File Open dialog to appear, which enables one to modify the Path Name field. $Command_6$ is used primarily by programmers.

Table 8.1 Channel Setting Group Reference

Settings Group settingType	**Field** fieldNum	**Field Description** fieldValue
Display -7		Defines the vertical scale of Record page Displays, and allows one to enable a channel for digitizing.
	Display$_1$	If Display$_1$ is set to On$_1$, the channel is enabled for digitizing when the Start button is pressed in the Record page = {On$_1$, or Off$_2$}.
	Disp Max EU$_2$	Specifies the Engineering Units value that corresponds to the top line of a Record page or Probe dialog snapshot display.
	Disp Min EU$_3$	Specifies the Engineering Units value that corresponds to the bottom line of a Record page or Probe dialog snapshot display.
Driver Ram -15		Defines a buffer, in RAM memory, that is maintained by the instruNet Driver. This is used by programmers to hold digitized data. For more information, please refer to Chapter *4, Programming*.
	Digitize$_1$	If Digitize$_1$ is set to On$_1$, the channel is enabled for digitizing, and the digitized data is sent to the Driver Ram buffer at runtime = {On$_1$, or Off$_2$}.
	Buffer Addr$_2$	This is the address, in RAM memory, of the Driver Ram Buffer; 0 if not used (off). The Buffer size corresponds to 1 Scan of data points, where each point is stored in a 32bit floating point number (4 bytes per point).
	Ptr Byte Size$_3$	This is the size of the Driver Ram Buffer in Bytes. This is often equal to 4 * PtsPerScan.
	Scan Num In$_4$	Scan Number of last data point pushed into Driver Ram Buffer = {1... numScans}.
	Pt Num In$_5$	Point Number of last data point pushed into Driver Ram Buffer = {1... PtsPerScan}
	Scan Num$_6$	Scan Number of last data point pulled out of Driver Ram Buffer by Access_Digitized_Data_In_Ram_Buffer() = {1...numScans}.
	Pt Num Out$_7$	Point Number of last data point pulled out of Driver Ram Buffer by Access_Digitized_Data_In_Ram_Buffer() = {1...PtsPerScan}.
File -17		Specifies a file that contains digitized data. This is used primarily by programmers. For more information, please refer to *Chapter 4, Programming*.
	File$_1$	If File$_1$ is set to On$_1$ the channel is linked to the file = {On$_1$, or Off$_2$}.
	Digitize$_2$	If Digitize$_2$ is set to On$_1$ the channel is enabled for digitizing, and the digitized data is sent to the Driver Ram buffer at runtime = {On$_1$, or Off$_2$}.
	File Name$_3$	Specifies the file name that is linked to the channel. This is often the same as the channel name (e.g. "Ch1 Vin+").

Table 8.1 Channel Setting Group Reference

Settings Group settingType	**Field** fieldNum	**Field Description** fieldValue
File -17 *Continued*	Command$_4$	Writing to the Command$_4$ field causes the following to occur (use the Record window Open/Save commands to connect with datasets on disk): File > Ram buf$_2$ Transfer Num Pts$_7$ (number of points) from the Scan Num$_5$ scan, starting at PointNum$_6$, from the File to the Driver Ram Buffer. If FileType is Binary Merge, this occurs for all channels stored in the file for this network. File > User buf$_4$ Same as File > Ram buf$_2$, yet to User Ram Buffer. Ram buf > File$_3$ Transfer the data in the Driver Ram Buffer to the file on disk. If FileType is Binary Merge, this occurs for all channels stored in the file for this network. User buf > File$_5$ Same as Ram buf > File$_3$, yet from User Ram Buffer. Get File Info$_6$ Get information about the File. Load {Scan Num$_5$ PointNum$_6$} with the last point in the file, and load Num Pts$_7$ with the number of points per scan .
	Scan Num$_5$	Refers to a scan number = {1...numScans}.
	PointNum$_6$	
	Num Pts$_7$	Refers to the number of points in the last Scan = {1...PtsPerScan}.
General -6		Specifies general information about a channel, such as its name and value.
	Value I/O$_1$	Specifies realtime value of the channel, in engineering Units. If the channel is a voltage input, this reflects the realtime voltage at the input terminals. If the channel is a voltage output, this is the voltage at the output terminals.
	Units Label$_2$	Specifies vertical label that is shown in the Record page and Probe dialog displays (e.g. "Volts", "C").
	User Name$_3$	Specifies the name of the channel that is shown in the displays (e.g. "Pressure1", "Temp2").
	% Sample Rate$_4$	Specifies the channel's sample rate as a percentage of the master sample rate that is defined in the Timing dialog (press Timing in Setup dialog) = {.001...100}. For example, if the master sample rate is 1Ks/sec, and Ch1's % Sample Rate$_4$ is set to 25, then Ch1 will digitize at 250s/sec.
Hardware -3 *with Voltage Input Channels*		Specifies parameters that control a Voltage Input channel. For more information, please refer to *Chapter 2, Working with Sensors*, and *Chapter 3, Connecting To Sensors*.
	Sensor$_1$	Specifies type of sensor attached to Voltage input terminals = { Voltage$_1$, Current$_2$, Resistance$_3$, Strain Gage$_4$, RTD$_5$, Types J$_6$, K$_7$, T$_8$, E$_9$, R$_{10}$, S$_{11}$, B$_{12}$, N$_{13}$ Thermocouple, Thermistor$_{14}$ }.
	Wiring$_2$	Specifies wiring at Voltage input terminals = { Vin+ - Vin-$_1$, Vin - Gnd$_2$, Shunt Resistor$_3$, Voltage Divider$_4$, Bridge$_5$, Quarter Bridge$_6$, Half Bridge Bend$_7$, Half Bridge Axial$_8$, Full Bridge Bend$_9$, Full Bridge Axial I$_{10}$, Full Bridge Axial II$_{11}$ }.

Table 8.1 Channel Setting Group Reference

Settings Group settingType	**Field** fieldNum	**Field Description** fieldValue
Hardware *Continued*	Low Pass$_3$	Specifies lowpass analog filter cutoff frequency in Hz (e.g. 0Hz = off, 40Hz, 4000Hz).
	Integrate$_4$	Specifies amount of integration (i.e. smoothing) in units of seconds. Signal are sampled and averaged for the duration specified in this field.
	Range$_5$	Specifies maximum input range for the measured voltage, in units of Volts. For the most accurate readings, specify the smallest range possible without causing the measured voltage to hit the bound. For example if your maximum expected input range is +-50 mV select a range of +-.3V (i.e. set the Range$_5$ field to .3).
Hardware -5 *with Digital I/O*		Specifies parameters that control a Digital I/O channel (e.g. Ch25 Dio on the Model 100 Device). For more information, please refer to *Chapter 2, Working with Digital I/O Channels.*
	Digital Output$_1$	Specifies the logic level of bits that have been set up as digital outputs in the Direction$_2$ field. Please see *Chapter 2, Working with Digital I/O Channels* for details on how this is done.
	Direction$_2$	Sets the direction of the various digital bits as an input (0) or an output (1).
Highpass Filter -9		Defines a digital highpass filter. For more information, please refer to *Chapter 2, Working with Digital Filters*.
	Filter$_1$	Selects filter model = {Off$_1$, Elliptic$_2$, Chebyshev P$_3$, Chebyshev S$_4$, or Butterworth$_5$ }
	PassB Ripple$_2$	Specifies maximum allowable passband ripple, in dB.
	StopB Attn$_3$	Specifies the minimum stop band attenuation, in dB.
	Filter Order$_4$	Displays filter order. Automatically determined by the filter design, which is based on the specified criteria.
	PassB F1 Hz$_5$	Frequencies above PassB F1 Hz$_5$ are passed.
	StopB F1 Hz$_6$	Frequencies below StopB F1 Hz$_6$ are attenuated.
	Pass B F2 Hz$_7$	Not used.
	Stop B F2 Hz$_8$	Not used.
Lowpass Filter -8		Defines a digital lowpass filter. For more information, please refer to *Chapter 2, Working with Digital Filters*.
	Filter$_1$	Selects filter model = {Off$_1$, Elliptic$_2$, Chebyshev P$_3$, Chebyshev S$_4$, or Butterworth$_5$ }
	PassB Ripple$_2$	Specifies maximum allowable passband ripple, in dB.
	StopB Attn$_3$	Specifies the minimum stop band attenuation, in dB.
	Filter Order$_4$	Displays filter order. Automatically determined by the filter design, which is based on the specified criteria.
	PassB F1 Hz$_5$	Frequencies below PassB F1 Hz$_5$ are passed.
	StopB F1 Hz$_6$	Frequencies above StopB F1 Hz$_6$ are attenuated.
	Pass B F2 Hz$_7$	Not used.
	Stop B F2 Hz$_8$	Not used.

Table 8.1 Channel Setting Group Reference

Settings Group settingType	**Field** fieldNum	**Field Description** fieldValue
Display Options -18		Specifies how waveforms are displayed and stored while digitizing. For more information, please refer to *Chapter 2, Digitizing Analog Signals into the Computer* and *Chapter 5, Display Options*.
	Horiz Scale$_1$	Specifies the horizontal scale of the displays in the Record page and Probe dialog (i.e. Seconds per horizontal division). Use 0.0 to enable automatic scale selection, which is based on the sample rate and Scan size.
	Horiz Pos$_2$	Specifies the horizontal position of the displays in the Record page and Probe dialog (i.e. seconds associated with the display left edge). This, in effect, is linked to the horizontal scrollbar.
	Plot$_3$	Specifies whether to plot one dot per data point, or to connect data points with lines = { Lines$_1$, or Dots$_2$ }. Lines$_1$ requires more processor time.
	Grid$_4$	Turns display grid on or off = { On$_1$, or Off$_2$ }.
	Max Pts/Pix$_5$	Sets the maximum number of points plotted in each vertical column of pixels.
	Digitize Into$_6$	Specifies where digitized data is saved = { Off$_1$, ToRamBuffer$_2$, ToFile$_3$, or UserControl$_4$ }.
	Overflow Alrt$_7$	Specifies whether or not the instruNet driver shows an alert when the Digitizer buffer overflows = { On$_1$, or Off$_2$ }.
Timer -14		Specifies the function of the Digital Timer I/O Channels on the Model 200 and 220 instruNet Controllers (not iNet-230). For more information, please refer to *Chapter 2, Working with Controller Digital Timer I/O Channels.*
	Function$_1$	Sets the channel function as one of = { Digital In$_1$, Digital Out$_2$, Clock Output$_3$, Period Measurement$_4$ }. See *Chapter 2, Working with Controller Digital Timer I/O Channels* for details.
	Clk Period$_2$	Sets the cycle time, in seconds, when doing Clock Output.
	Clk Out Hi$_3$	Sets the high time, in seconds, when doing Clock Output.
	Measure$_4$	When doing Period Measurement, this specifies if the cycle time or the high time is measured = { Cycle Time$_1$, or High Time$_2$ }.
	Meas. Resol.$_5$	When doing Period Measurement, this specifies the measurement accuracy to one of = { .25µs$_1$, or 4ms$_2$ }.
	Meas. Cycles$_6$	When doing Period Measurement, this specifies the number of cycles or high times that must elapse during the measured duration = {0...255}.

Table 8.1 Channel Setting Group Reference

Settings Group settingType	**Field** fieldNum	**Field Description** fieldValue
Timing -12		Specifies parameters for the DSP based digitizing via the Model 200, 220 and 230 instruNet Controllers. For more information, please refer to *Ch2, Digitizing Analog Signals into the Computer*, & *Ch 5, Timing Options*.
	Digitize$_1$	Turns digitizing on or off for all channels = { On$_1$, or Off$_2$ }. This field is automatically set to On$_1$ when the Start button is pressed and Off$_2$ when the Stop button is pressed.
	Pts Per Scan$_2$	Specifies the number of points digitized for each Scan, at the master Sample Rate$_5$.
	No. of Scans$_3$	Specifies the number of Scans that are digitized when the Start button is pressed.
	Scan Mode$_4$	Specifies whether consecutive Scans are continuous with respect to each other = { Strip Chart$_1$, Oscilloscope$_2$, Oscillo Queued$_3$ }. Please refer to *Chapter 5, Strip Chart and Oscilloscope Scan Modes*, for details.
	Sample Rate$_5$	Specifies the master sample rate, in units of samples-per-second-per-channel. If the specified rate is too fast, instruNet will adjust to the fastest possible rate. All channels run at this rate, unless their % Sample Rate$_4$ field is requesting a slower rate.
	Min sec/tsfr$_6$	Specifies the minimum acceptable time to transfer a 16bit value on the instruNet network, in units of seconds.
	Network BPS$_7$	Specifies the instruNet network data transfer rate in bits per second = {100,000 ...4,000,000}. This is automatically set to the fastest possible rate when instruNet is reset. Long network cables and/or many network Devices sometimes require a slower rate.
	Switching$_8$	Specifies analog channel switching to run Fast$_2$ or Accurate$_1$. If Fast is used, the system switches from one channel to another as fast as possible; otherwise, with Accurate, the switching is a little slower, yet provides the amplifiers more time to settle, and is therefore a little more accurate.

Table 8.1 Channel Setting Group Reference

Settings Group settingType	**Field** fieldNum	**Field Description** fieldValue
Trigger -13		Specifies the Trigger condition that must be met before digitizing (after the Start button is pressed). For more information, please refer to *Chapter 2, Digitizing Analog Signals into The Computer*, & *Ch 5, Trigger Options*.
	Trigger$_1$	Sets the trigger mode to one of: { Off$_1$, Auto$_2$, or Norm$_3$ }. Off$_1$ specifies no trigger, Norm$_3$ mandates that the digitizing cannot begin until the trigger condition is met, and Auto$_2$ waits for the trigger condition yet digitizes anyway if the condition is not met within several seconds.
	Threshold EU$_2$	Specifies the trigger threshold in engineering units (EU).
	Slope$_3$	Specifies the direction the waveform must cross the threshold in order to trigger = {Rising$_1$, or Falling$_2$}.
	Expansion$_4$	
	Trig. Net#$_5$	Specifies the Network number of the trigger channel.
	Trig. Dev#$_6$	Specifies the Device number of the trigger channel.
	Trig. Mod#$_7$	Specifies the Module number of the trigger channel.
	Trig. Chan#$_8$	Specifies the Channel number of the trigger channel.
User Ram -16		Defines a buffer, in RAM memory, that is maintained by the programming end user. This buffer is used to hold digitized data. For more information, please refer to Chapter *4, Programming*.
	Digitize$_1$	If Digitize$_1$ is set to On$_1$, the channel is enabled for digitizing, and the digitized data is sent to the User Ram buffer at runtime = {On$_1$, or Off$_2$}.
	User Addr$_2$	This is the address, in RAM memory, of the User Ram Buffer; 0 if not used (off). The Buffer size must be enough to hold 1 Scan of data points, where each point is stored in a 32bit floating point number (4bytes/point).
	Buff Byte Size$_3$	This is the size of the User Ram Buffer in Bytes. This must be greater than or equal to 4 * PtsPerScan.
	Scan Num In$_4$	Scan Number of last data point pushed into User Ram Buffer = {1... numScans}.
	Pt Num In$_5$	Point Number of last data point pushed into User Ram Buffer = {1... PtsPerScan}
	Scan Num$_6$	Scan Number of last data point pulled out of User Ram Buffer by Access_Digitized_Data_In_Ram_Buffer() = {1...numScans}.
	Pt Num Out$_7$	Point Number of last data point pulled out of User Ram Buffer by Access_Digitized_Data_In_Ram_Buffer() = {1...PtsPerScan}.

Table 8.1 Channel Setting Group Reference

9 *instruNet* BASIC

Overview

instruNet BASIC enables users to automate the setting up of channels, digitizing, viewing results, and saving to disk. It is predicated on the BASIC programming language, and features many additional commands that facilitate working with instruNet hardware. instruNet BASIC builds on the instruNet World strip chart recorder, by automating common tasks done at experiment time. This is especially helpful at reducing the chance of error, and making the data taking process more pleasant. A person who is not too familiar with the computer, doing many manual steps, at a fast pace, under pressure, can lead to a problem. instruNet BASIC addresses that issue by consolidating a series of steps into one button press in the instruNet World window.

This manual assumes the user is familiar with the BASIC programming language.

Software License

instruNet BASIC is built into Ver 1.25 or later of instruNet World software and runs in demonstration mode unless a Software License has been registered. This license is included with iNet-200s, iNet-220s, iNet-230s and iNet-350 products, and is installed as described in *Chapter 1, instruNet BASIC Software License Installation*. Demonstration mode is very similar to Licensed mode, except measured data is sometimes simulated with fake triangle wave data.

BASIC Page

Code is developed in the BASIC page, which is enabled by pressing the BASIC tab at the base of the instruNet World window. This page contains a text editor that supports typing, placing an insertion point, scrolling vertically, selecting text, Cutting text to the clipboard, Copying text to the clipboard, and Pasting text from the clipboard. The text editor is used to create, edit, view, execute, and test instruNet BASIC files, which are based in standard text files, and appear as regular unformatted text.

Buttons

Several buttons at the top of the BASIC page aid in the programming process. The BASIC Page **Open** button loads text files into the text editor and the **Save**/**Save As** buttons save the text editor contents to a text file on disk. The **Clear** button clears the text editor and the **Execute** button executes the entire contents of the text editor as BASIC code; unless a portion of text had been selected with the mouse, in which case, only that portion is executed. If a line is not recognized, an alert appears, execution halts, and the problematic line of code is selected in the text editor. The **Stop** button stops all currently executing instruNet BASIC code.

Benefits

What can instruNet BASIC do for ME ?

instruNet BASIC can create more text editor pages within instruNet World for data and notes, each with their own tab at the base of the window. And BASIC can easily print notes and data to these pages, save the text to disk, and load text from disk. Also, with several lines of BASIC code, one can spool digitized data to disk in one large text file, filling a 2 GByte file at rates of approximately 5000 points/second. instruNet BASIC can also create buttons at the top of the instruNet World window that execute BASIC code when pressed. Buttons can be used to set up the calibration of channels, record data, save data, and view data. instruNet BASIC can declare a list of channels, that are many channels long, and then with one line of code, globally set a field (e.g. sensor type, wiring, integration) for each of those channels. This enables one to set up channels without manually setting fields within the instruNet Network page. For more details, please see the text files in folders "instruNet\ BASIC\ Examples\ ", and "instruNet\ BASIC\ Documentation\". One can read these by pressing the BASIC tab at the base of the instruNet World window, pressing the Open button, and then navigating to the instruNet\ BASIC\ directory.

Print Digitized Channels Example

The following code creates a button called "Record" that, when pressed, digitizes 3 points from several channels and prints the results to an instruNet World text window, in a table-like format. As shown below, each channel has its own column and each dataset its own row.

```
Ch1 Vin+          Ch4 Vin+
Volts             Volts
1.231531e-2       3.976332e0
1.899534e-2       2.453343e0
```

The code that produces this table, in realtime, is shown below:

```
NewButton Test "Record"          ; create a new button in the Test Page
                                 ; tell user what we are going to do
  Alert "We are now going to record.  Press Mouse to Stop."
                                 ; print the following to the Test page:
                                 ;  XYZ Data: date=xx/yy/xz, time=pp:dd:qq
  Print Test "\rXYZ Data: date=" date   ", time=" time  "\r\r"
  Calibrate Hardware             ; calibrate instruNet Hardware
                                 ; define a list of channels
  Define MYCHAN# "1/1/1/1, 1/1/1/4"
                                 ; print header to the Test page
  Table MYCHAN# general user_name   Test "\t" "\r" 16
  Table MYCHAN# general units_label Test "\t" "\r" 16
  Loop 3 1 mouseStop             ; print 3 rows, 1per-sec, mouse down to stop
                                 ; print the value of each channel in the list
    Table MYCHAN# general value_input Test "\t" "\r" 16
  Endloop                        ; end of loop
EndButton                        ; end of button
```

The `NewButton Test "Record"` command defines a new button. The two parameters after `NewButton` are the instruNet World pageName (e.g. Test, BASIC,

new-user-page1, new-user-page2) and the new button name. When this button is pressed, the code between the NewButton command and EndButton command (i.e. the "body") is executed. This button causes about 10 lines of code to be executed. The ";" and "//" characters indicate that a comment follows, and is ignored by the interpreter. The first command is an **Alert** that displays the text in quotes in an alert box. Alerts are helpful at guiding the user during an experiment. The above **Print** command prints several lines of text to the Test page. The first Print parameter refers to a page (e.g. Test, BASIC, new-user-page1) followed by quoted text which is printed as is. Keywords like 'time' and 'date' are substituted with the current time or date. The "\r" and "\t" within the quoted text are replaced with a carriage return and tab, respectively. The previous **Calibrate Hardware** command tells instruNet to calibrate all hardware and to correct for any minute temperature related drifts in the measurement circuitry, which is a nice thing to do before acquiring data. The **Define** statement specifies a list of channels, and assigns the name `MYCHAN#` to that list. Each channel is referred to by its network#/ device#/ module#/ channel# address. For example, 1/1/1/4 refers to Ch4 in Module #1, of Device #1, attached to Network #1. The list of channels can be quite long, and are referred to with a Define name, which is a unique word that ends in a "#" character. The Define statement can be used to consolidate a long string into one word, and when that word later appears in the code, the interpreter substitutes the Define text for that word. The syntax of the Define command is:

`Define` *name# substitutionText*

The previous **Table** command line prints a field's value for a list of channels. The first Table command in the above example prints the channel name field, the second Table command prints the units-label field, and the third Table command prints the value of each channel three times (due to the `Loop 3 1 mouseStop`). The `"\t" "\r" 16` in the Table commands tells the interpreter to place a tab between each column, a carriage return at the end of the row, and pad each point with spaces so that each point consumes exactly 16 characters. The **Loop** command tells the interpreter to execute the body of the loop 3 times, at a rate of once through the loop every 1 second, and a mouse down will cause the interpreter to fall out of the loop (to allow the user to stop early). Another way to stop execution is to press the Stop button in the BASIC page. Another way to digitize, is to use the Digitize command, which consolidates the loop and table commands into 1 line of code, and is capable of moving data more quickly. Both the Table and Digitize commands can send date to the instruNet World text editor, or a file on disk of up to 2GBytes in size. For an example of the Table and Digitize commands, please see file "instruNet\ BASIC\ Examples\ TakeData.iBs".

Feedback Control Example

The code below prints the value of the several channels and then enters a feedback loop. The loop runs until the mouse is pressed. An example of printed output text is shown the below. The value of channel Ch1 Vin is printed once a second on the last line of the printout.

```
Ch1 Vin     = -1.935999155045
Ch3 Vout    = 0.5221114754677
Ch25 Dig In = 231

Cycle    Chan#1
    4    -0.256
```

The `ch1Value! = channel(VIN1#)` line reads the value of channel Ch1 Vin into variable ch1Value!. The following print command prints the loop number in 5 integer digits, and then prints Ch1 in floating point format with 3 digits to the right of the decimal. The `Synchronize 1` command causes the loop to execute once each second. The following code sets outputs depending on the state of channel Ch1 Vin. For the source code to this example, please see "instruNet\ BASIC\ RW_Chan.iBs".

```
Delete Variables
Define VIN1#  1/1/1/1                ; Ch1 Vin+
Define VOUT3# 1/1/1/3                ; Ch3 Vout
Define DIO#   1/1/1/25               ; Ch25 Digital I/O
print "\r"                           ; print value of several channels
print "\rCh1 Vin     = " (channel(VIN1#))
print "\rCh3 Vout    = " (channel(VOUT3#))
print "\rCh25 Dig In = " (channel(DIO#))    "\r"
print "\rCycle    Chan#1\r"
cycle! = 0
while 1                              ; loop until mouse is pressed
  ch1Value! = channel(VIN1#)         ; get value of Ch1 Vin+ channel
                                     ; print formatted Ch1 Vin channel
  print %5d:cycle! "    "  %+2.3f:ch1Value!
  cycle! = cycle! + 1
  Synchronize 1                      ; execute loop once every 1sec
  if (mouseB == true) then end
  erase 1                            ; erase last printed line of text
                                     ; set output bit depending on Ch1 Vin
  if (ch1Value! > 3) then SetChannelBit DIO#  1  4
  if (ch1Value! < 2) then SetChannelBit DIO#  0  4
  if (ch1Value! > 5)                 ; set Ch3 Vout depending on Ch1 Vin
     SetChannel VOUT3# (ch1Value! / 2)
  else
     SetChannel VOUT3# (ch1Value! / 4)
  endif
endwhile
end
```

Channel Setup and Calibration Example

The code below sets up a batch of strain gages and a batch of thermocouples. For source code similar to this example, please see files "instruNet\ BASIC\ Examples\TakeData.iBs" and file "instruNet\ BASIC\ Documentation\Template.doc".

```
Define GAGES# "1/1/1/1, 1/1/1/4"                    ; strain gages channels
Define TCs#   "1/1/1/7, 1/1/1/10"                   ; thermocouples channels
Define ALLCH# "1/1/1/1, 1/1/1/4, 1/1/1/7, 1/1/1/10" ; all channels

NewButton Data "Setup"
                                                    ; ----- SETUP STRAIN GAGES -----

  SetF GAGES# General    Units_Label   "uStrain"    ; vertical units label
  SetF GAGES# Mapping    Scale          1.0e6       ; Internal to External EU mapping
  SetF GAGES# Hardware   Wiring         Q_Bridge    ; wiring type
  SetF GAGES# Hardware   Sensor        Strain_Gage  ; sensor type
  SetF GAGES# Hardware   Integrate      0.016       ; integration secs for 1 reading
  SetF GAGES# Hardware   Range         "+- 10mV"    ; Voltage range, in Volts
  SetF GAGES# Constants  Ro             350         ; bridge resistance, in ohms
  SetF GAGES# Constants  GF             2.155       ; strain gage factor
  SetF GAGES# Constants  "delta,_Rlead" 3.8         ; bridge lead resistance
  SetF GAGES# Constants  Vout           4.5         ; excitation output voltage
  SetF GAGES# Display    Disp_Max_Eu    +4000       ; Display Top, in Eng. Units
  SetF GAGES# Display    Disp_Min_Eu    -4000       ; Display Bottom, in Eng. Units

                                                    ; ----- SETUP THERMOCOUPLES -----

  SetF TCs#   General    Units_Label   "C"          ; vertical units label
  SetF TCs#   Hardware   Wiring    "Vin+  -  Vin-"  ; wiring type
  SetF TCs#   Hardware   Sensor       T_Thermocpl  ; sensor type
  SetF TCs#   Hardware   Integrate      0.016       ; integration secs for 1 reading
  SetF TCs#   Hardware   Range         "+- 10mV"    ; Voltage range, in Volts
  SetF TCs#   Display    Disp_Max_Eu    +100        ; Display Top, in Eng. Units
  SetF TCs#   Display    Disp_Min_Eu     0.0        ; Display Bottom, in Eng. Units

  Alert "Thank you.  All channels are now set up."
EndButton
```

The above example makes extensive use of the **SetField** command (abbreviated "SetF"). The syntax for the SetField command is:

`SetField` *chList settingsGroup fieldName newFieldValue*

The first parameter of the SetField command refers to a list of channels. This could be one channel (e.g. 1/1/1/4), a list of channels (e.g. "1/1/1/1, 1/1/1/4"), or a define name# that was previously set to either of these. The above example uses two channel lists, one for strain gages, and one for thermocouples. The second SetField parameter is the Setting name (e.g. General, Constants, Hardware), which corresponds to the Settings popup choices inside the Network page Probe Dialog. The third parameter is the field name, which corresponds to the names of the fields in the Probe Dialog. For details on these fields, please refer to Chapters 2, 3, 5, and 8.

The forth parameter is the new value for the field, which is set for all channels in the specified list.

The following example creates a button that balances the strain gage channels when pressed. Balancing involves measuring the voltage across the bridge when the gage is unstrained (i.e. 0 uStrain) and then loading this value into the Vinit field within the Constants setting group.

```
NewButton Test "Balance"            ; create new button in Test page
  Alert "Please apply 0 strain and then press OK."
  Calibrate GAGES# Vinit            ; balance all strain gages
  Alert "Thank you.  That was good."
EndButton
```

The "**Calibrate** *chList* Vinit" command loads the Vinit field with the voltage at the channel screw terminals, for every channel in the chList, and subsequently balances the bridges with one line of code. If one did "Calibrate *chList* Int1", then the value of each channel would be loaded into the Mapping Internal1 (or Internal2 if Int2 was specified) field, to facilitate two point calibration.

File I/O Example

The code below creates a button called "Save As" that saves the contents of the Test page to disk in a text file.

```
NewButton Test "Save As"            ; create new button in Test page
  Create "MyNewFile" showDialog     ; create a new file via the File Save dialog
  Copy Test MyNewFile               ; copy contents of 'Test' page into the file
  Close MyNewFile                   ; close the file
EndButton
```

The **Create** command creates a new file on disk. The first parameter is the file's name, and subsequent code must reference this file by this internal filename. The 2nd parameter is a keyword that specifies the directory in which the file is saved. Keyword 'showDialog' instructs the interpreter to show the File Save dialog, and let the user decide where to place the file. Other directory keywords are 'appDir', which refers the same directory as the application file; 'osDir', which refers to the Operating System directory where the instruNet driver is kept; and 'masterDir', which is a global pathname that can be moved to any folder via the **SetMasterDir** command. In the above example, the **Copy** command is used to copy the contents of the Test page to the new, open, file. The syntax of the Copy command is:

`Copy` *sourceText pageFileOrStr_destination*

This command copies the source text (e.g. page, file, variable!, string$, define#, numerical constant, or text in quotes) into the specified destination page, open file, or string$. In the above example, the **Close** command closes the open file when finished.

In general, files must first be established with the Create or Open command. Create creates a new file, whereas Open opens an existing file. Once a file is open, it is read to or written from via the Print, Table, Digitize, Clear, Copy and Append

commands. Then, when finished, it must be closed with the Close command. To close all open instruNet files, simply execute "Close All". In general, one can write data either to an instruNet text window, or to an open file. The text windows provide visual feedback, whereas direct to text file is faster and disk based files can be up to 2GBytes in length. For an example of file I/O, please see file "instruNet\ BASIC\ Examples\ File_rw.iBs".

Programming Example

The code below shows an example use of the For, Loops, While, Goto/Label, If/Then, and If/Elseif/Else/Endif commands.

```
for f! = 1 to 3                          ; For ctr! = start To end

   print "\r"
   if (f! == 1)                          ; If...Elseif...Elseif...Else
      print "f! = 1"
   elseif (f! == 2)
      print "f! = 2"
   else
      print "f! > 2"
   endif
                                         ; one line If...Then...
   if (f! == 2) then print ", inside-if"

   w! = 0
   while (w! < 2)                        ; While ()... Endwhile
      w! = w! + 1
      print ", w! = "w!
   endwhile

   i! = 0
   loops 2                               ; Loops
      print ", i! = " i!
   endLoops

   goto LabelOne                         ; Goto...Label
LabelTwo:

Next
end

LabelOne:
   print ", inside goto."
   Goto LabelTwo
```

When this code is executed, the following text is printed:

```
  f! = 1, w! = 1, w! = 2, i! = 0, i! = 0, inside goto.
  f! = 2, inside-if, w! = 1, w! = 2, i! = 0, i! = 0, inside goto.
  f! > 2, w! = 1, w! = 2, i! = 0, i! = 0, inside goto.
```

The **For** command facilitates a loop with a loop variable. The **If** / [**elseif**] / [**else**] / **endif** commands allow one to make decisions. **While** continues to loop while the

test case is true; while, **Loops** loops a fixed number of times. **Goto** jumps to a **Label**, and labels are simply a unique word, suffixed with a ":" character. For an example use of these commands, please see "instruNet\ BASIC\ Examples\ program.iBs".

Mathematical Expressions

A powerful feature within the instruNet BASIC is the ability to evaluate mathematical expressions. Parameters passed to functions with enclosing parenthesis are first evaluated mathematically. For example `Print (2 * 3)` prints the number "6". One can nest several parenthesis within one expression. For example, `var! = ((2 + 3) * (3 + 4))` correctly evaluates to 35. Objects within parenthesis are evaluated numerically. This means that one can place variables!, strings$, and defines# within a mathematical expressions. For example, if v! = 2, s$ = "3", and def# = "4"; then `((v! * s$) + def#)` evaluates to 10. And many common mathematically functions are also supported. For example, "(abs(-1))" calculates the absolute value of the -1 argument, returning +1. One can enter constants as integers (e.g. 3, -3), floating point numbers (e.g. 3.1, 2.12), scientific notation values (e.g. 1.34e-10), hexadecimal numbers with a "0x" prefix (e.g. 0xAC01), and binary numbers with a "0b" prefix (e.g. 0b01010). To operate on bits within 32bit integer values, one can use bitwise bOr (|), bAnd (&), bEor (^), 1's complement (comp()), left-shift (<<), and right-shift (>>) operators. Logically, "false" is represented as 0, and "true" as non-zero (e.g. 1). Logical operators "And" and "Or" facilitate the comparison of two Boolean values. Conditionally, the instruNet BASIC supports less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), equal to (==) and not equal to (!=).

The math evaluator supports several keywords: "ticks" returns the value of the computer's internal tick counter (1000Hz clock on Win95/NT, and 60Hz clock on Mac), "tSecs" returns the value of the tick counter in seconds units, "iSecs" returns the value of the instruNet hardware clock in units of seconds (which is a 62bit, 4MHz clock), "mouseB" returns 1 if the mouse button is down and 0 otherwise, "mouseX" returns the mouse horizontal pixel position, "mouseY" returns the mouse vertical pixel position, "true" returns 1, and "false" returns 0. For examples of mathematical expressions, please see file "instruNet\ BASIC\ Examples\ MathExp.iBs". The following operators and functions are supported by instruNet BASIC:

Math Operators

Operator	Notation	Example
Add	(*arg1* + *arg2*)	(3 + 2) = 5
Subtract	(*arg1* - *arg2*)	(2 - 3) = -1
Multiply	(*arg1* * *arg2*)	(4 * 3) = 12
Divide	(*arg1* / *arg2*)	(6 / 3) = 2
Modulo (remainder of x/y)	(*x* % *y*)	(5 % 3) = 2

Bitwise Operators

Operator	Notation	Example
Bitwise And	(*arg1* & *arg2*)	(0b0101 & 0xf) = 5
	(*arg1* bAnd *arg2*)	(0b0101 bAnd 0xf) = 5
Bitwise Or	(*arg1* | *arg2*)	(0b0101 | 0x7) = 5
	(*arg1* bOr *arg2*)	(0b0101 bOr 0x7) = 5
Bitwise Eor	(*arg1* ^ *arg2*)	(0b0101 ^ 0x7) = 2

	(*arg1* bEor *arg2*)	(0b0101 bEor 0x7) = 2
Bitwise Shift Left	(*arg1* << *arg2*)	(0b0101 << 2) = 20
Bitwise Shift Right	(*arg1* >> *arg2*)	(20 > 2) = 5
1's Complement	comp(*arg*)	comp(0x0f) = 0xf0
Return *bitNum* value	GetBit(*arg* : *bitNum*)	GetBit(8 : 3) = 1
Set *bitNum* bit to 1	SetBit(*arg* : *bitNum*)	SetBit(0 : 3) = 8
Set *bitNum* bit to 0	ClrBit(*arg* : *bitNum*)	ClrBit(8 : 3) = 0

Logical Operators

Operator	Notation	Example
Logical And	(*arg1* && *arg2*)	(1 && 1) = 1
	(*arg1* And *arg2*)	(true And true) = 1
Logical Or	(*arg1* || *arg2*)	(0 || 0) = 0
	(*arg1* Or *arg2*)	(false Or false) = false
Not	not(*arg*)	not(true) = false

Conditionals

Conditional	Notation	Example
Less than	(*arg1* < *arg2*)	(4 < 5) = true
Greater than	(*arg1* > *arg2*)	(4 > 5) = false
Less than or equal to	(*arg1* <= *arg2*)	(5 <= 5) = true
Greater than or equal to	(*arg1* >= *arg2*)	(3 >= 5) = false
Not equal to	(*arg1* != *arg2*)	(4 != 5) = true
Equal to	(*arg1* == *arg2*)	(4 == 5) = false

Basic Functions

Function	Notation	Example
Absolute Value	abs(*arg*)	abs(-3.1) = +3.1
e to the x'th power	exp(*s*)	exp(3.9) = 49.4
Natural log, base 2	ln(*arg*)	ln(3) = 1.09
Logarithm, base 10	log(*arg*)	log(3) = .47
Reciprocal = 1/x	recip(*x*)	recip(10) = 0.1
Square = x * x	sqr(*x*)	sqr(4) = 16
Square Root = x ^ 1/2	sqrt(*x*)	sqrt(16) = 4
x to y'th power	pow(*x* :*y*)	pow(2 : 3) = 8

Round Off Functions

Function	Notation	Example
Round to closest integer	int(*arg*)	int(3.1) = 3
Round down to integer	RndDn(*arg*)	RndDn(3.1) = 3
Round up to integer	RndUp(*arg*)	RndUp(3.1) = 4
Value to right of decimal	fract(*arg*)	fract(1.2345) = .2345

Statistical Functions

Function	Notation	Example
Minimum of x & y	min(*x* :*y*)	min(9 : 10) = 9
Maximum of x & y	max(*x* :*y*)	max(9 : 10) = 10
Average of x & y	avg(*x* :*y*)	avg(9 : 10) = 9.5

String Functions

Function	Notation	Example
length of string	sLen(*string*)	sLen("abc") = 3
string compare	sCompare(*s1, s2*)	sCompare("ab", "ab") = 1
string search	sSearch(*s1, s2*)	sSearch("abcdef", "cd") = 3
string to ascii value	sAscii(*string*)	sAscii("a") = 97

***instruNet* Hardware**

Function	Notation	Example
value of instruNet channel	channel(*n/d/m/c*)	channel(1/1/1/1) = 2.31351

Trig. Functions (radians units)

Function	Notation	Example
Cosine (radians units)	cos(*arg*)	cos(1) = .54
Sine	sin(*arg*)	sin(13.5) = .8
Tangent	tan(*arg*)	tan(1) = 1.55
Arc Cosine	acos(*arg*)	acos(.25) = 1.31
Arc Sine	asin(*arg*)	asin(.25) = .252
Arc Tangent	atan(*arg*)	atan(.25) = .244
Arc Tan of x/y	atant(*x :y*)	atant(3 : 4) = .64
Hyperbolic Cosine	cosh(*arg*)	cosh(25) = 3e10
Hyperbolic Sine	sinh(*arg*)	sinh(3) = 10
Hyperbolic Tangent	tanh(*arg*)	tanh(1) = .76

Temperature Conversion Functions

Function	Notation	Example
Celsius to Fahren.	CtoF(*Celsuis*)	CtoF(100) = 212
Fahren. to Celsius	FtoC(*Fahrenheit*)	FtoC(32) = 0
Celsius to Kelvin	CtoK(*Celsius*)	CtoK(0) = 273.16
Kelvin to Celsius	KtoC(*Kelvin*)	KtoC(100) = -173.16
Fahren.to Kelvin	FtoK(*Fahrenheit*)	FtoK(273.16) = 32
Kelvin to Fahren.	KtoF(*Kelvin*)	KtoF(32) = 273

Numerical Constants

Format	Notation	Example
Integer	+/-xxxxxx	-3, 312312
Floating Point	+/-xxx.yyy	3.1, -1221.1213
Scientific Notation	+/-xx.yyyezz	-1.123e-10
Hexadecimal	0xHHHHHH	0x12A, 0xacf0c2
Binary	0bxxxxxxxx	0b01, 0b1101011

Base Keywords

Interpretation	Keyword	Example
logical true = 1	true	(true) = 1
logical false = 0	false	(false) = 0
0	zero	(zero) = 0.0
2 ^ 31 - 1	end	(end) = 2147483646
pie = 3.14	pie	(pie) = 3.14159
e = 2.718	e	(e) = 2.718
Mouse Up(0)/Down(1)	mouseB	(mouseB) = 1
Mouse X coordinate	mouseX	(mouseX) = 418
Mouse Y coordinate	mouseY	(mouseY) = 321

Time Keywords

Interpretation	Keyword	Example
60Hz/1KHz Counter	ticks	(ticks) = 232411.21
Tick counter in secs units	tSecs	(tSecs) = 324.23
secs since 1/1/94	bSecs	(bSecs) = 1712233376
4MHz instruNet clock	iSecs	(iSecs) = 123.12
current month	cMonth	(cMonth) = 1
current day	cDay	(cDay) = 1
current year	cYear	(cYear) = 98
current hour	cHour	(cHour) = 12
current minute	cMinute	(cMinute) = 21
current second	cSecond	(cSecond) = 42

Debugging

Below are several techniques that aid the debugging process.

1. An alert typically appears when the instruNet BASIC interpreter hits a problematic line of code, alerting the user to a specific problem. Also, if the code is executing out of the BASIC page, the problematic line is automatically selected in the text editor.

2. Enable debugging by placing the following in your program code: `Debug On`. This causes debugging information to be printed to the BASIC page each time a line of code is executed.

3. Add print statements to your code to indicate progress as it executes. One could print to the BASIC page, or the Test page (i.e. "Print BASIC ..." or "Print Test …").

4. Press the Stop button at the top of the BASIC page to stop execution of all code, if you think it is stuck in an infinite loop.

Objects

instruNet BASIC works with the following objects:

Program Code instruNet BASIC contains a list of commands that are recognized by the instruNet BASIC interpreter. This code can be loaded into an instruNet window for execution, or can be executed directly from a file via the Execute command.

Commands Each command (e.g. Alert, Print) resides on one row in the code file, where the first word is the command, and parameters follow, separated by spaces. Unless a parameter is in quotes, capitalization is ignored. One parameter cannot contain a space (' ') character; otherwise, the interpreter would think you have 2 parameters. To indicate a space, underscore characters "_" are sometimes substituted. If you want spaces or you want to retain capitalization's, the entire parameter must be enclosed in quotes "...".

Pages & Buttons The instruNet World software provides environments for working with instruNet, called "pages", each of which are selected with a tab at the base of the instruNet World window. Record, Network, Test, and BASIC are standard pages included with instruNet. Additionally, the user can create new pages (with an associated tab) with the NewPage command. User created pages contain a text editor in the body of the window, and a row of user created buttons at the top that execute code when pressed.

Variables! instruNet BASIC supports variables that are stored internally as 8byte floating point numbers. Variable names are suffixed with the "!" character (e.g. "var!", "x!"), and are often defined with an equal "=" sign (e.g. `var! = 3.2`) . Variables can be passed as parameters to functions (e.g. `Loop ctr!`) and many commands support variables as destination or source arguments (e.g. `print var! (abs(a!+b1))`).

**Strings$** instruNet BASIC supports string variables. These contain text and can be of any size, memory permitting. Strings names are suffixed with the "$" character (e.g. "str$", "abc$"), and are often defined with an equal "=" sign (e.g. `str$ = "initialText"`) . Strings can be passed as parameters to functions (e.g. `v! = sin(str$ + 2)`) and many commands support strings as destination or source text (e.g. `copy strA$ strB$`).

Defines# The Define command tags a name to a segment of text, enabling one later in the code to use that name instead of the original text segment. For example, `Define MYCHANNELS# "1/1/1/1, 1/1/1/4"` allows one to use the name `MYCHANNELS#` later in the code to refer to the list of channels. Define names themselves must end in a "#" character, to indicate they are a define name. Defines# are similar to strings$, in that they contain text, yet unlike strings, they are typically written to once when they are initially defined.

Object Database instruNet World contains an internal database of variables!, strings$, and defines#. These objects are global, in that any code fragment can read from or write to them. They are non-volatile in that they remain alive even when a code stops executing, so that another fragment can use them. "Delete Variables" deletes all objects in the database, and "Clear Variables" sets all variables! to 0.0 and all strings$/defines# to no-text.

Comments Comments are preceded by ";" or "//". A row of text can begin with a comment, or one can place a comment after a command an its parameters.

Channel Address Channels are specified with a 4 number address, separated by "/" characters in netNum/deviceNum/moduleNum/chanNum order. For example, "1/2/3/4" refers to netNum#1, deviceNum#2, moduleNum#3, and chanNum#4.

Channel Lists To specify a list of channels, enclose the entire list of channel addresses in quotes "...", and separate each address with a space character " ", comma "," or tab "\t". For example, "1/1/1/1, 1/1/1/4" refers to Channel#1 and Channel#4. Channel lists can be defined using multiple rows of text (i.e. it is ok to place a carriage return between two channel addresses).

Text Files The text within user defined Pages is easily saved to disk in a text file. Alternatively, one can write directly to a text file, without first viewing the data (via the Print, Table, Digitize, Clear, Copy and Append commands). A number of commands in the language manage files, including: Open, Create, Copy, Append, Clear, Print, SetSize, Flush, and Close. The instruNet text windows can contain a maximum of 32K characters; however, a file on disk can be up to 2GBytes in length.

BASIC Files instruNet BASIC code is typically saved in a text file, with the ".iBs" suffix.

"Startup.iBs" This instruNet BASIC file is executed when the instruNet window is first opened, if it exists in one of the following folders: "WinNT\System32\", "Win95\System\", or "Mac\ System\ Extensions\"; or within the directory that contains the currently executing application program (e.g. the directory that contains the instruNet World program itself). To create a startup file, develop your script in the instruNet BASIC page, and then save it with the name "Startup.iBs" to one of the previously mentioned directories. Then exit instruNet World, and run it again to see if your startup script executes upon program launch.

Version 1.25 Version 1.25 or later of the instruNet software contains the instruNet BASIC feature, with documentation in the "instruNet\ BASIC\ Documentation\" directory and examples in "instruNet\ BASIC\ Examples\". Also, Chapter 9 of the instruNet Manual contains extensive documentation on this powerful feature.

Code Syntax

Command Line A line of instruNet BASIC begins with the name of the command followed by a list of parameters, with space characters separating each parameter, e.g. "commandName param1 param2 param3". We don't use commas, since they are used by many European nations as decimals (e.g. in Germany, "1,2" means "1.2"), and instruNet BASIC supports numerical expressions with a comma in the decimal point.

[item1/item2/...] Brackets [] are used to describe a parameter that must be passed as one item from a given list, where the list is encapsulated in brackets [..], and the items within the list are separated with "/" characters. For example, the syntax "Debug [On/Off]" refers to a command that is expressed as "Debug On" or "Debug Off".

Italics Parameters that are shown in *italics* are to be defined by the user; whereas parameters shown in non-italics are keywords that are to be typed as shown. For example, the Close command is described as follows:

`Close` [*fileName* /`all`]

This command has one parameter that is either *fileName*, or the keyword "all". When one uses this command to close a specific file, they would refer to that file's name; otherwise, they would use the keyword "all" to close all open files.

(parameter) Parameters shown in parenthesis (...) are optional. For example, "Loop *numCycles* (*secsPerLoop*)" describes a command with one mandatory parameter, *numCycles*; and one optional parameter, *secsPerLoop*. One could express this command as "Loop 3" or "Loop 3 .1", yet not simply as "Loop". If the *secsPerLoop* parameter in this example is not included, the loop runs as fast as possible, without a secsPerLoop synchronizer.

"Text" Quotes are used to encapsulate text that retains spaces & capitalization's. For example, `Alert "Is anyone there?"` displays the quoted text exactly as shown. If text is not in quotes, space characters indicate a new parameter and capital letters are converted to lower case by the interpreter. Subsequently, non-quoted code is not sensitive to lower-case/upper-case discrepancies.

Math Expressions Encapsulating a parameter in parenthesis (...) causes it to be mathematically evaluated for a value. For example, `Print (3+2)` prints "6". For details, please see the previous "Math Expressions" discussion.

\r and \t Backslash characters followed by an "r" or "t" (i.e. "\r" & "\t") are used to indicate carriage-return or tab characters within quotes. For example `Print "A = 1\rB = 2\rC = 3\r"` prints 3 rows of text.

Floating Point Floating point numbers must use a decimal point "." to separate the integer and fractional part (e.g. "1.8" refers to 1 and 4/5).

Object Names String names must be suffixed with the "$" character, variables names with the "!" character, and define names with the "#" character.

Object Management Commands

`Append` *pageFileStrVarDefine_source pageFileStrVar_destination*

Appends the text in the specified source object [e.g. string$, variable!, define#, "quotedText", (math expression), or numerical constant] to the destination string$, variable!, page or open file. For example, `Append BASIC Test` would append the text in the BASIC page onto the end of the text in the Test page. `Append "abc" str$` would append "abc" onto the end of the existing text in string str$.

`Clear [all/variables/pages/userPages/buttons/files/`*pageName /fileName*`]`

Clears the specified objects of their data. "Clear Variables" clears all variables (strings$, vars!, defines#) of their data, "Clear userPages" clears the text in the pages created with the NewPage command, "Clear Buttons" deletes the buttons created with the NewButton command, "Clear files" sets the filesize of all open files to 0 and in effect clears them of data, "Clear *pageName*" clears the specified text editor (e.g. Test, BASIC, user-defined-page1), "Clear *fileName*" clears the specified open file, and "Clear All" clears all previously mentioned items.

`Copy` *pageFileStrVarDefine_source pageFileStrVar_destination*

Copies the text in the specified source object [e.g. string$, variable!, define#, "quotedText", (math expression), or numerical constant] to the destination page, string$, or open file. For example, `Copy BASIC Test` would copy the text in the BASIC page into the Test page. `Copy "abc" str$` would copy "abc" onto string str$. String Copy is very similar to string Append, yet replaces the destination text with the source text, instead of appending it.

`Define` *name# substitutionText*

Substitutes *substitutionText* for *name#*, every time name# appears later in the program code. Define names must end in a "#" character. Substitution text can be of any length yet must be enclosed in quotes "..." if it contains spaces or capital letters. Also, the substitution text can appear on multiple lines within the text file, in the event it is lengthy. Defines are similar to strings$, except they are typically set once, and read often; whereas strings$ are typically set multiple times.

`Delete [all/variables/pages/buttons/files]`

Deletes the specified sets of objects from memory. "Delete Variables" deletes all variables!, strings$ and defines# from memory; "Delete Buttons" deletes user created buttons from memory, "Delete pages" deletes user created pages, and "Delete All" deletes all previously mentioned items.

String$* = ("*quoted text*") (*numbers*) (*var!*) (*str$) (*def#*) (*math expression*)

Copies a concatenated list of text items to the specified string. This is the same as the Print command, except the destination string is first cleared before text is concatenated onto it. For example, `a! = 9.8, b$ = "abc", Str$ = a! + "--" + b$ + " " (3 + a!) + b$[2 : 3]` causes Str$ to be loaded with "9.8--abc 12.8bc". For details, please refer to the documentation on the Print command.

Variable! = *math expression*

Loads the specified variable with the result of the math expression. For example, `a! = 2, s$ = "3.2", v! = abs(a! + s$) + 3` causes v! to be loaded with 8.2. For details, please see the previous discussion on Math Expressions.

Programming Commands

`Debug [on/off]` Toggles debugging on or off. If on, diagnostics are printed to the BASIC page for each line of code that is executed. This can be useful when debugging code that is not working properly. Also, adding additional Print statements to your code (e.g. `Print BASIC ...`, `Print Test ...`) can aid in debugging as well.

`End` Stops program execution. All variables!, defines#, and strings$ remain alive and well, until one does "Delete Variables", "Clear Variables", or exits instruNet World.

`Execute` *pageFileOrStr*

Executes the text in the specified page, open file or string$. With files, one must first use the Open command to open an existing file, or the Create command to create a new file, and then close the file with the Close command when done.

`For` *variable!* = *Start* `To` *Stop* `... Next`

This is the traditional For loop, which facilitates a loop with a control variable that increments by 1 each time through the loop, starting at *Start*, and going until *Stop*. For example, the code below prints Channel#1 three times.

```
For c! = 1 to 3
   Print "Cycle=" c! ", Ch1 Vin=" (Channel(1/1/1/1)) "\r"
Next
```

`Goto` *label* `...` *label:*

Labels are unique words by themselves on one line with a ":" suffix (e.g. `StageTwo:`). They are ignored when executed directly, yet instead are used as targets for a Goto *Label* statement. For example, the code below continuously prints Channel#1.

```
TakeData:
   Print "Ch1 Vin=" (Channel(1/1/1/1)) "\r"
   Goto TakeData
```

`If (`*mathExpression*`) ... [elseif (`*mathExpression*`)] ... [else] ... endif`

The If/Elseif/Else/Endif commands facilitate executing specific fragments of code, depending on a mathematical test. The Elseif components can be repeated many times, providing a means by which one can include many different cases. Endif must be placed at the end of the decision tree. Below is an example of an "If" based decision tree.

```
if (x! == 0)
   print "x! is 0"
elseif (x! == 1)
   print "x! is 1"
else
   print "x! is not 0 and not 1"
endif
```

`If (`*mathExpression*`) then` *commandToExecuteIfMathExpressionIsTrue*

This is a one line version of the traditional "If (mathExp) ... EndIf", where only one line of code is executed if the math expression is true. There is no body of code and no EndIf command in this one-line version. For example, `If (a! < 2) then Beep` sounds a beep if variable a! is less than 2.

`License` *yy-ssssss-yyyyy*

Registers the 13 digit instruNet BASIC license, and enables BASIC for your computer. This license is printed on a sheet of paper included with the iNet-200s, iNet-220s, iNet-230s and iNet-350 products. The license command saves the license number in the Operating System directory; therefore, one only has to do this once while the current OS directory is in service. The license is in a zz-ssssss-yyyyy format, where ssssss matches the serial number of the controller card (i.e. #iNet-2x0). The license for each controller card is unique. If you purchased instruNet BASIC #iNet-350, you will need to contact your supplier to make sure you get a license number that matches your controller card.

`Loop` *numCycles* `(`*secsPerLoop*`) (mouseStop) ... EndLoop`

Executes the code between Loop and EndLoop *numCycles* times. If the *secsPerLoop* parameter is not specified, the loop executes as fast as possible; otherwise, it executes the body of the loop once every *secsPerLoop* seconds. If keyword 'mouseStop' is included, it falls out of the loop if the mouse button is pressed. One can also stop by pressing the Stop button at the top of the BASIC page.

`Synchronize` *secsPerLoop*

When placed inside a loop (e.g. While, For, Loop), this causes the synchronizer causes the loop to execute once every *secsPerLoop* seconds.

`While (`*mathExpression*`) ... EndWhile`

This is the traditional While loop, which executes the body for as long as the math expressions evaluates as true. For example, the code below prints Channel#1 three times.

```
c! = 1
while (c! <= 3)
   c! = c! + 1
   Print "Cycle=" c! ", Ch1 Vin=" (Channel(1/1/1/1)) "\r"
endwhile
```

User Interface Commands

`Alert` *alertText* — Shows an alert with the specified alert text, which could be in the form of "quoted text", a string$, or a define#. For example, `Alert "Hello"` would show an alert with "Hello" in the body of the dialog.

`Beep` — Sounds a short beep.

`Delay` *seconds* — Implements a delay that is *seconds* long. For example, `Delay (1+ 2)` would implement a 3 second delay. One can stop the delay only by pressing the Stop button at the top of the BASIC page.

`Erase` *pageName numOfLines*

Erases the last *numOfLines* lines from the specified page. For example, `Erase BASIC 1` would erase the last line of text from the BASIC text editor page.

`Print (`*PageOrFile*`) ("`*quoted text*`") (`*numerical value*`) (`*var!*`) (`*str$*`) (`*def#*`) (`*math expression*`) (time) (date) (variables)`

Prints a list of items to the specified destination page (i.e. tab at bottom of window), or open file. If the first parameter after Print is not a file or page, the printing is directed to the current page. If keywords 'time' or 'date' is in the list, the current time or date are substituted for those keywords. Text in quotes is printed exactly as is. The list of items (i.e. quoted text, time, date, variables!, strings$, defines#) can appear in any order and be of any length. "\r" and "\t" within quoted text is interpreted as a carriage return or tab character, respectively. Items within parenthesis ( ) are first evaluated mathematically (e.g. `(3 + abs(a! - 3))` in the item list would be evaluated mathematically and its result would be printed). For many examples of the print command, please see file "instruNet\ BASIC\ Examples\ Print.iBs". `Print Variables` causes all variables to be printed. To print a range of a string, supply the start and stop indices into the string array, base 0, within square brackets. For example, `print str$[3 : 5]` prints the 3 characters from string str$ after the first 4 characters. One can separate the items in the print list with a space character, or the + plus symbol. For example, `Print a + b + c  d  e` prints "abcde". To print value in a floating point format (from a variable!, string$ or define#); prefix `%`*x*`.`*y*`f:` to the object name, where *x* is the number of digits to the left of the decimal, and *y* is the number of digits to the right of the decimal (e.g. `Print %1.3f:var!` would print var! in a x.yyy numerical format). To force scientific notation, use `%`*x*`.`*y*`e:`. To allow the compiler to decide floating point or scientific notation, use `%`*x*`.`*y*`g:`. To force a integer printout, use `%xd`. instruNet BASIC uses the same numerical formatting conventions as ANSI C/C++. To learn more about this, please consult a book on the ANSI C library, and focus on the printf() function and the general topic of "printing numbers".

`Question` *questionText responseStr$* (*defaultResponseText*) (*pressedRightBtnVariable!*) (*leftBtnText*) (*rightBtnText*)

Shows a dialog box that asks a questions, provides an edit field area for the user to type a response, and two buttons (e.g. OK and Cancel). The response is placed into string *responseStr$* and variable *pressedRightBtnVariable!* is set to true (1) if the user pressed the right button to exit the dialog; and is set to false (0).otherwise. Optionally, the response field can contain a default response that appears when the dialog is first opened. And one can specify the labeling of the two buttons *leftBtnText* via and *rightBtnText.* For example, `Question "How old are you?" response$ "20" userPressedRightBtn! "Cancel" "OK"` would show an alert with the "How old are you?" question, and a default response of 20 with Cancel/OK exit dialog buttons.

Button and Page Commands

`NewPage` *pageName*

Creates a new tab at the bottom of the instruNet World window that selects a text editor region. For example, "NewPage Data" creates a new tab named "Data" and a new text editor region that appears when Data is pressed. Subsequent code can then reference this region with the pageName "Data". For example, `Print Data "Hello\r"`, would print the word "Hello" to the Data page.

`NewButton` *pageName buttonName* `....` `EndButton`

Creates a new button that executes the code between NewButton and EndButton when pressed. *pageName* specifies the page that the button is to reside, and *buttonName* specifies the text that appears inside the button at the top of the window. Button names are typically less than 9 characters in length. Subsequent commands refer to this button by its *buttonName* .

`Press` *pageName buttonName*

This command automatically presses *buttonName* in page *pageName*. For example, "Press Network Open" causes the Network File Open dialog to appear. If we created a new page called "Data", and placed a new button into this page called "Calibrate", then executing "Press Data Calibrate" would be the same as if the user had pressed that button herself/himself.

`Select` *pageName*

Selects page *pageName*, and displays its contents. This is similar to pressing a tab at the base of the window. For example, "Select Record" causes the Record page to appear.

`[Show/Hide]` *pageName*

Shows or hides a tab at the base of the window. For example, "Hide Network" hides the Network tab at the base of the window, and prevents the user from selecting it.

`[Show/Hide]` *pageName buttonName*

Shows or hides a button at the top of the window. For example, "Hide BASIC Execute" hides the Execute button in the BASIC page, preventing the user from pressing it.

Data Acquisition Commands

`Calibrate Hardware`

Implements full instruNet hardware calibration. This takes several seconds and is used primarily to correct for minute measurement errors caused by temperature drifts.

`Calibrate Gages`

This does a 0 uStrain calibration for all channels that are set up as strain gages by reading the voltage across the bridge, and placing it into the Constants Vinit field, for each strain gage channel.

`Calibrate Bridges`

This balances all channels that are set up with a Bridge wiring type by reading the voltage across the bridge, and placing it into the Constants Vinit field, for each bridge channel.

`Calibrate VDividers`

This balances all channels that are set up with Voltage Divider wiring by reading the voltage across the sense resistor, and placing it into the Constants Vinit field, for each voltage divider channel.

`Calibrate` *chList* `Vinit`

For each channel in the *chList*; the Vinit fields are loaded with the measured voltage. The Vinit fields are used to balance a bridge.

`Calibrate` *chList* `[Int1/Int2]`

For each channel in the *chList*; the Mapping Internal1 or Internal2 fields are loaded with the measured engineering units value. This facilitates doing a two point calibration via the Mapping Setting Group.

`Digitize` *chList sRate nPts* (*PageFileOrStr*) (*separator*) (*lastRowChar*) (*charPerCol*) `(mouseStop) (time)`

Digitizes the channels in the *chList* channel list at the specified samples-per-second-per-channel (*sRate*) and number-of-points-per-channel (*nPts*). Data is printed to the specified page, open file or string; with each channel in its own column. If keyword 'mouseStop' is included in the command line, a mouse down aborts the data taking (also, pressing Stop in the BASIC pages stops execution). If keyword 'time' is included in the command line, then the point time is placed in the left-most column of

the resulting printed table. For a description of the *separator, lastRowChar, and charPerCol* parameters, please see the "Table" description, below.

`SetChannel` *chList newValue*

Sets the value of each channel in the *chList* to the specified *newValue.* This is most applicable with voltage output and digital output channels. For example, `SetChannel 1/1/1/3 2.0` sets Ch3 Vout to 2.0 Volts.

`SetChannelBit` *chList* `[0/1]` *bitNum*

Sets the bitNum bit of each channel in the *chList* to the specified 0 or 1 value. This is most applicable with digital output channels. For example, `SetChannel 1/1/1/25 0 3` sets Ch25 Dout bit #3 to 0.

`SetField` *chList settingsGroup fieldName newFieldValue*

Sets field *fieldName* in *settingsGroup* to *newFieldValue* for every channel in the *chList* channel list. Please see file "instruNet\ BASIC\ Documentation\ Template.doc" for examples of SetField (which can be abbreviated "SetF"). Also, for more information, please see the "Channel Setup and Calibration Example" discussion found earlier in this chapter, and the below discussion about the Table command.

`SetTrigger` *triggerSource_chList threshold* `(rising/falling) (off/auto/norm)`

Sets the digitize trigger source channel (e.g. 1/1/1/4), *threshold*, slope (keywords 'rising' or 'falling') and mode (keywords 'off', 'auto', or 'norm'). For example, "SetTrigger 1/1/1/1 2.0 rising auto" would tell the Digitize command to not digitize until the voltage at Channel #1 rose above 2.0.

`Table` *chList settingsGroup fieldName* (*pageFileOrStr*) (*separator*) (*lastRowChar*) (*charPerCol*)

Prints the value of the specified field for every channel in the list, on one row of text. If a destination Page, string, or open file is not specified, then it prints to the current window. The channel list is stated explicitly (e.g. "1/1/1/7, 1/1/1/10"), or through a define name#. The *settingGroup* parameter refers to a settings area (e.g. Hardware, General, Mapping) and the *fieldName* parameter refers to the name of a field (e.g. scale, wiring, sensor). For a list of these, please see Chapter 8, file "instruNet\ BASIC\ Documentation\ Template.doc", or the previous "Channel Setup and Calibration Example" discussion. The optional *separator* parameter is text that is placed between each data point (e.g. "\t" is a tab), and the optional *lastRowChar* parameter is text that is placed at the end of each row (e.g. "\r" is a carriage return). The optional *charPerCol* parameter specifies the number of characters dedicated to each point, padding with spaces (" ") when necessary. For an example, please see "Print Digitized Channels Example", found earlier in this chapter.

File Commands

For a discussion of file issues and a review of example files code, please see the "File I/O Example" discussion found earlier in this chapter.

`Close [`*fileName* `/all]`

Closes the specified open file; or, if keyword 'all' is specified, closes all open instruNet files.

`Create` *fileName* `[masterDir/showDialog/lastDialog/osDir/appDir]`

Creates a file with the specified file name in the specified directory. Keyword 'showDialog' invokes the File Save dialog to allow the user to specify the OS file name (which is different from *fileName* used by the code to keep track of the new file) and file save location; keyword 'lastDialog' causes the new file to be placed in the same directory as the last file I/O operation; keyword 'osDir' causes the file to be placed in the operating system directory (i.e. "WinNT\System32\", "Win95\System\", or "Mac\ System\ Extensions\"); keyword 'appDir' causes the new file to be placed in the same directory as the currently executing application program; and keyword 'masterDir' causes the file be placed at an internal pathname called the "Master Directory". One can set the Master Directory with the "SetMasterDir" command, described below.

`Flush [`*fileName* `/all]`

Writes pending data to disk for the specified open file. This is not necessary, since data is flushed periodically automatically, yet is here to allow additional control over internal file buffers.

`Open` *fileName* `[masterDir/showDialog/lastDialog/osDir/appDir]`

Opens the specified file in the specified directory. For details on the directory options, please see the above discussion on the "Create" command.

`SetMasterDir [showDialog/lastDialog] (newFolder)`

Sets the master directory pathname via a file open dialog ('showDialog'), or to the last used pathname ('lastDialog'). Keyword 'newFolder' causes a new folder to be created. After being set, this global pathname can be used to direct other file I/O operations.

`SetPointer` *fileName byteIncrement* `[fromStart/fromEOF/fromPos]`

All open files have an internal pointer that refers to the last written to or last read from byte location (starting with 0). The SetPointer command moves this pointer a relative amount forward or backward from the 1st byte of the file ('fromStart'), the end of the file ('fromEOF') or from the current position ('fromPos'). If the *byteIncrement* value is positive, the pointer is moved forward; otherwise, it is moved backward.

`SetSize` *fileName* `[`*numBytes* `/toPointerPosition]`

Sets the size of the specified open file to a specific number of bytes; or if keyword 'toPointerPosition' is used, to the location that was last read from or written to. Before spooling a large amount of data to disk, it is often helpful to preset the filesize, so that new space on the disk is not constantly being allocated during data acquisition time.

I Troubleshooting

If your instruNet system is not operating properly, use the information in this chapter to isolate the problem. If the problem appears serious enough to warrant technical support, please contact your instruNet supplier.

Identifying Symptoms and Possible Causes

Use the Troubleshooting information in the following table to try to isolate the problem. This table lists general symptoms and possible solutions for problems with instruNet hardware and software.

Symptom	Possible Cause	Possible Solution
Computer crashes when instruNet World is run.	The Controller board is not seated properly, or it is damaged.	Check the installation of the Controller hardware and instruNet software per directions in *Chapter 1*. Try rebooting the computer. Also, refer to the next section of this chapter entitled "... your controller is not seen by the instruNet World Software" paying careful attention to the discussion about making sure the card is properly seated in its connector.
Digitized waveforms appear to be invalid.	An open connection may exist on a channel.	Check the wiring to the input terminals.
	The sensor is not wired correctly.	Refer to Chapter 5 for instructions on wiring sensors.
	The Field settings are not correct.	Refer to *Chapter 5 Sensors Reference*, *Chapter 7 Channel Reference* & *Chapter 8 Settings Reference*. It is recommended that Chapter 2 instruNet World Tutorial be completed before attempting to wire sensors.
	A Channel is configured as a single-ended input while the transducer is a differential type, or vice-versus.	Check the wiring to instruNet and the Wiring settings. Check the transducer type.
Computer will not boot	The Controller board is not seated properly, or is damaged.	Check the installation of the Controller hardware and instruNet software per the directions in *Chapter 1*.

Table AI-1 Troubleshooting

Symptom	Possible Cause	Possible Solution
instruNet World opens, yet does not see Controller (i.e. only 3 rows of data are displayed in Network).	The Controller board is not seated properly, or is damaged.	Please refer to the next section of this chapter for information on this scenario.
	Driver is not compatible with your computer.	Install latest version of driver, available for free at www.instrunet.com. Beware that if the driver files are also in the same directory as the application (e.g. in the same directory as "instruNet World"), the application may use those driver files instead of the one's in your operating system directory; therefore, make sure that both are current (or delete the driver files in the same directory as the application).
instruNet World opens ok, yet does not see an instruNet 100 Device	instruNet 100 device is not connected to the instruNet controller by an instruNet cable, or instruNet cable is not well seated.	Use a flash light to make sure connectors at the controller end and device are well seated. Some computers have a small corridor through which the instruNet cable must pass through to get to the instruNet controller DB-25 connector, and in some cases, this hole is not large enough, and subsequently requires reducing the size of the instruNet cable molding with a knife.
	instruNet box is radiating at a high frequency w.r.t. Earth Ground	Attach a short 18 gauge local ground wire from instruNet Box GND terminal, to a local Earth Ground.
	instruNet Terminator not attached to the end of the network.	Check Terminator.
	Blown power fuse (e.g. 5V, -12V or +12V) in the Device, or in the Controller (which could have been caused by plugging in devices while the power is on). instruNet 100 units manufactured after 9/1/97 contain resettable fuses that automatically reset after blown.	To test if your fuses are ok, measure the voltages at the 5V, -12V and +12V screw terminals on the instruNet 100. For example, to measure the +5V voltage, place one voltmeter lead on the "+5V" screw terminal and the other lead on the "GND" screw terminal. If the voltage is off by more than +/1V, a fuse is probably blown in either the instruNet 100 or the Controller card. Please contact your instruNet supplier if this is the case.
	Bad instruNet Cable.	Try another cable.
	Broken Controller or Device.	Consult your instruNet supplier.

Table AI-1 Troubleshooting

If the instruNet PCI Controller Board is not seen by the instruNet World software...

After installing the instruNet software per Chapter 1, one can easily verify its installation by running the instruNet World software. If on Windows 95/NT, select "instruNet World" in the "instruNet" group within the START menu to run instruNet World. When this software first opens, a list of instruNet resources are listed in a spreadsheet like format. If only 3 rows of information are displayed, then the software only sees the driver; if 15 rows are displayed then the Controller (e.g. PCI) is seen as well; and if 40 rows are displayed, then an instruNet 100 network device is also seen. Also, to verify that these three items are installed, one can click on the TEST tab at the bottom of the window, and press the SEARCH button to display a list of installed resources (e.g DRIVER, CONTROLLER, DEVICE).

If the Controller (e.g. pci card) is not seen on a Computer, then please proceed with the following steps:

1. Use a flash light to make sure the board is well seated in its connector. With some computers, it is difficult to insert the tab at the bottom of the I/O fence into its receptacle. Sometimes, the I/O fence at the back of the computer is not registered with respect to the motherboard, and tightening the I/O fence screw causes the card to enter its connector at an angle. If this happens, leave the screw loose and make sure the card is properly aligned in its connector so that the pcb finders correctly align with their mating receptical pins.

2. Turn the computer power off for 10 seconds, turn it back on to boot the computer, and then run "instruNet World" to see if the card is found. If it is not found and you are running on a Windows 95/NT computer, please power the computer off, and then on again, since re configuring the cards internally sometimes requires two power off/on cycles (sometimes due to plug-and-play arbitration going on inside the computer).

3. If running under Windows 95/NT, make sure "iNet32.DLL" Version ≥ 1.23 is installed in the System directory, within the Windows directory (i.e. Win95\System\iNet32.dll; or WinNT\System32\iNet32.dll).

   If on a PPC Macintosh, make sure "instruNet Driver (ppc)" Version ≥ 1.23 is installed in the System's Extensions folder.

   If on a 68K Macintosh, make sure "instruNet Driver (68K&FPU)" Version ≥ 1.23 is installed in the System's Extensions folder.

   If running under Windows NT, make sure you log on as the Administrator before running Setupex.exe, and then restart your computer after running the Setupex.exe. Also, make sure that file "inet.sys" is installed at "WinNT\system32\driver/inet.sys".

   The latest software is available for download, free of charge, at www.instrunet.com.

Beware that if the driver files are also in the same directory as the application (e.g. in the same directory as "instruNet World"), the application may use those driver files instead of the one's in your operating system directory; therefore, make sure that both are current (or delete the driver files in the same directory as the application).

4. If on a Windows computer: If you are running a video accelerator, try turning it off, and see if this helps.

5. If your computer has several ISA or PCI cards that are not necessary for computer operation (e.g. sound card, fax/modem card, scsi card, etc) then it is recommended that you unplug them one at a time (while power is off), boot the computer (for each case) and run the instruNet software.

6. It is possible the controller is broken. To detect this, try a different computer or a different controller.

7. With older computers, it is sometimes possible that an old ISA card driver is conflicting with a new PCI card. A conflict resolution program such as "First Aid", or reinstalling the OS software, might remedy the problem.

8. If running under Windows 95 with an instruNet PCI card, and instruNet Version ≤ 1.22 was previously installed on this computer, and you are now running >1.22, then it might be necessary to remove some debris from the older software. To do this, run The "System" Control Panel, select "Device Manager", select "View Devices by connection", expand "PCI bus", if you see "? PCI Card" select it & press the Remove button, and exit "System" Control Panel. Then, reboot your computer, and when it asks for a PCI driver, Navigate via the Browse button to "Program Files \ instruNet \ Win95 iNet PCI Driver \ inet95.inf". This inf file is installed on your computer when you run the >1.22 instruNet Setupex.exe file. Then run "instruNet World" software and look for >14 rows in the Network page, indicating that it found the pci controller (if only 3 are shown, it means that it found the Driver software, yet not a controller card).

9. If the above steps did not remedy the problem, add the word "debug_" to the instruNet World application name (e.g. change it to "instruNet World debug_"), run "instruNet World debug_", a text file named "iNetDiag.txt" will be created and saved into the system directory ("Extensions" Folder on Macintosh, "Win95\System" Directory on Windows 95, and "WinNT\System32" Directory on Windows NT) with diagnostic information (if on Ver ≥ 1.21), and then fax or email this to your supplier. This will tell the supplier specifically where it is having trouble, and they will then get back to you with further suggestions. After generating this report, restore the "instruNet World" application name to its original form. Also, if running under Windows 95/NT, it is recommended that you also send a System Report at the same time to your supplier, as described in the next step.

10. If on a Windows 95/NT computer: Fax or email a copy of the Windows System Resource Report to your instruNet supplier. A 7 to 9 point font is ok for fax; however, email is sometimes easier, since this report can be 5 to 15 pages long. To create a copy of this report:

a) If on Windows 95: Run Windows "Explorer", Open the "Control Panels" folder, double-click on "System", select "Device Manager" tab, press "Print", select "All devices and system summary", select "Print To File" & press "OK".
b) If on Windows NT: Select "Windows NT Diagnostics" in the "Administrative Tools" group within the START menu, press the PRINT button, select "Complete" Detail, select "File" Destination, and then press "OK".

The report will be printed to the file specified in the Save dialog, which can be faxed or emailed to your supplier, who will be able to advise you further.

11. If on a Windows 95/NT computer, please request the instruNet application note on buggy PCI bios's.

instruNet Technical Support Form

If all else fails, please contact your instruNet supplier. To do so, please duplicate the following form, fill it out, and then fax or send it to your instruNet supplier. Also do the following:

- Check the installation of your hardware & software per the directions in *Chapter 1*.
- Check all cabling and connections and make sure they are secure.
- Determine if the cause of the problem is repeatable, and if possible, document the sequence of steps to reproduce the problem.
- **If you are telephoning for support, please call from a phone next to the computer on which your instruNet System is installed.**

End User

Name _____

Company/University _____

Address _____

Fax (____)_____Phone (____)_____E-mail _____

Computer

Computer Manufacturer/Model _____

Processor_____Operating System/Version number _____

RAM (MB)_____HD Capacity (MB) _____

Hardware

instruNet Controller's and Network Devices _____

_____

Software

instruNet Driver Version # _____

Application Software & Version # (if applicable) _____

Compiler & Version # (if applicable) _____

Problem

I am encountering the following problems _____

_____

_____

_____

_____

instruNet returned the following error codes or messages _____

_____

To reproduce the problem, do the following steps _____

_____

_____

_____

_____

_____

II *instruNet* Error Codes

The table below lists error codes returned by the instruNet driver along with possible causes and solutions to the problem. These are instruNet error codes, and are very different from your operating system error codes.

Error Code	Error Label	Possible Cause	Possible Solution
0	iNetErr_-None	no error	The operation was successfully completed.
1	iNetErr_-General	potentially anything	Try doing things differently and hope it goes away.
2	iNetErr_-Controller-NotInitialized	instruNet has not been initialized	Check cables. Try pressing the Reset button. See *Chapter 1.*
3	iNetErr_-InitFailed	instruNet initialization failed	Check network cables and termination. Check software installation. Try pressing the Reset button.
4	iNetErr_-DeviceNum-OutOfRange	Device number (deviceNum) is out of range	Make sure all hardware Devices are connected and powered on. Press Search button in Test page for list of registered Devices. Make sure the specified 'deviceNum' is correct. See *Chapter 1.*
5	iNetErr_-ChannelNum-OutOfRange	Channel number is out of range	Make sure the specified 'chanNum' channel number parameter is correct. See *Chapter 7.*
6	iNetErr_-FieldNum-OutOfRange	Field number is out of range	Make sure the specified 'fieldNum' field number parameter is correct. See *Chapter 8.*
7	iNetErr_-ControllerNot-Found	instruNet Controller not found	Make sure the specified 'netNum' network number parameter is correct. Press Search button in Test page for list of registered Networks. See *Chapter 1, Hardware Installation.*
8	iNetErr_-FieldDoesNot Exist	specified {netNum, deviceNum, moduleNum, chanNum, settingNum, fieldNum} does not exist	Make sure the specified 'netNum', 'deviceNum', 'moduleNum', 'chanNum', 'settingNum', 'fieldNum' parameters are correct. See *Chapter 8.*

Table AII - Error Codes

9	iNetErr_-BadfieldNat-iveDataType	bad data type	Make sure the specified 'netNum', 'deviceNum', 'moduleNum', 'chanNum', 'settingNum', 'fieldNum' parameters are correct. See *Chapter 8.*
10	iNetErr_-BadField-ReadType	bad read type	Make sure the specified 'netNum', 'deviceNum', 'moduleNum', 'chanNum', 'settingNum', 'fieldNum' parameters are correct. See *Chapter 8.*
11	iNetErr_-Timeout-AtReadBegin	time out at controller, crashed controller	Press Reset Button.
12	iNetErr_-TimeoutAt-WaitFor-ReadDone	time out at controller (crashed controller?)	Press Reset Button.
13	iNetErr_-Controller-IsInWeeds	crashed controller	Press Reset Button.
14	iNetErr_ill-egalDataType	bad data type	Make sure the specified 'netNum', 'deviceNum', 'moduleNum', 'chanNum', 'settingNum', 'fieldNum' parameters are correct. See *Chapter 8.*
15	iNetErr_-FailedCopy-DataTest	failed the CopyWaveData() test or bad instruNet Driver file	Try reinstalling installing Driver file and make sure you install correct version of Driver.
16	iNetErr_-Compressor-HitError	compressor hit error	Press Reset Button.
17	iNetErr_-FailedRam-Test	failed board ram test	Power Computer off, then on. Press Big Test button in Test page. Disconnect network cable from Controller to see if that fixes it. Controller might need service.
18	iNetErr_-RanOutOf-Memory	instruNet Driver ran out of memory	Try giving calling application program more memory. Try reducing the number of points per scan. Try a computer with more RAM.
19	iNetErr_-AlertFailed	the routine that shows an alert failed	Try reinstalling installing Driver file and make sure you install correct version of Driver.
20	iNetErr_-CtrlrRom-NotBooting	instruNet Controller's ROM does not seem to boot up (poss problem: controller, bus, rom)	Power Computer off, then on. Press Big Test button in Test page. Disconnect network cable from Controller to see if that fixes it. Controller might need service.
21	iNetErr_-CtrlrRam-NotBooting	instruNet Controller's driver in RAM does not seem to boot up (poss problem: controller, bus, ram, rom, download from uC, bad driver downloaded)	Power Computer off, then on. Press Big Test button in Test page. Disconnecting network cable from Controller might help. Controller might need service. Latest version of instruNet Driver might help.
22	iNetErr_-DriverDown-loadFailed	the download of the uController driver into uC ram failed (driver may be bad, or hardware is bad) (the keys did not match).	Power Computer off, then on. Press Big Test button in Test page. Disconnecting network cable from Controller might help. Controller might need service. Latest version of instruNet Driver might help.

Table AII - Error Codes

23	iNetErr_-CtrlrRW-TestFailed	failed during controller rw test in Test_DualPort_Ram()	Power Computer off, then on. Press Big Test button in Test page. Disconnecting network cable from Controller might help. Controller might need service. Latest version of Driver might help.
24	iNetErr_-Interface-BlockTest-Failed	Interface block between uController and host computer is invalid	Power Computer off, then on. Press Big Test button in Test page. Disconnecting network cable from Controller might help. Controller might need service. Latest vers. of instruNet Driver might help.
25	iNetErr_-IncCounter-TestFailed	Controller failed CounterInc test	Power Computer off, then on. Press Big Test button in Test page. Disconnecting network cable from Controller might help. Controller might need service. Latest vers. of instruNet Driver might help.
26	iNetErr_-EchoCmd-ToStatus-TestFailed	Controller failed EchoCmdToStatus test	Power computer off, then on. Press Big Test button in Test page. Disconnecting network cable from Controller might help. Controller might need service. Latest vers. of instruNet Driver might help.
27	iNetErr_-Controller-BootTest-Failed	Controller failed Test_A_Booted_Controller test	Power Computer off, then on. Press Big Test button in Test page. Disconnecting network cable from Controller might help. Controller might need service. Latest vers. of instruNet Driver might help.
28	iNetErr_-Controller-FailedToBoot	Controller failed to Boot.	Power Computer off, then on. Press Big Test button in Test page. Disconnecting network cable from Controller might help. Controller might need service. Latest vers. of instruNet Driver might help.
29	iNetErr_-Controller-CmdFailed	Controller failed to execute command	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
30	iNetErr_GUI	error related to graphical user interface	Try reinstalling installing Driver file and make sure you install correct version of Driver.
31	iNetErr_-QSPI_Busy	QSPI is busy running	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
32	iNetErr_-QSPI_Halted	QSPI hit HALT error	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
33	iNetErr_-QSPI_Arg-OutOfRange	QSPI argument out of range	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
34	iNetErr_-QSPI_-TimeOutErr	QSPI hit time out error	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
35	iNetErr_-FlakyNet-work	QSPI is acting flaky	Check instruNet network cables. Make sure a network terminator is properly installed. See *Chapter 1, Hardware Installation.*
36	iNetErr_-CouldNot-LocateDriverFile	could not find instruNet Driver file in system folder	Make sure you installed the correct instruNet Driver file at the correct location on your computer. See *Chapter 1, Software Installation.*

Table AII - Error Codes

37	iNetErr_-netNumOut-OfRange	netNum is out of range	Make sure the specified 'netNum' network number parameter is correct. Press the Search button in the Test page for a list of registered Networks. See *Chapter 1, Hardware Installation*.
38	iNetErr_-SettingGro-upNumOut-OfRange	setting GroupNum is out of range	Make sure the specified 'settingGroupNum ' setting group number parameter is correct. Press the Search button in the Test page for a list of registered Networks and Devices. See *Chapter* 7 & *Chapter* 9.
39	iNetErr_-UnitType-OutOfRange	deviceType is out of range	Check instruNet network cables. Make sure a network terminator is properly installed. See *Chapter 1, Hardware Installation*.
40	iNetErr_-DriverDid-NotSetErr-Code	Driver did not get a chance to set the error code; therefore Driver, or interface to Driver, is in trouble	Check the interface to Driver. Make sure you installed the correct instruNet Driver file at the correct location on your computer. See *Chapter 1, Software Installation*.
41	iNetErr_-SettingGroup-TypeOutOf-Range	settingGroupType is out of range	Make sure the specified 'settingGroupType' setting group type parameter is correct. Press the Search button in the Test page for a list of registered Networks and Devices. See *Chapter 8.*
42	iNetErr_-ModuleNum-OutOfRange	Module number is out of range	Make sure the specified 'moduleNum' module number parameter is correct (it is usually 1). Press the Search button in the Test page for a list of registered Networks and Devices.
43	iNetErr_-Intention-NumOutOf-Range	Intention number is out of range	Make sure the specified 'intention' intention number parameter is correct. See list of valid 'ion_intention' values in interface .h file.
44	iNetErr_-ReadOnly-Field	Cannot write to this field, read only	Make sure the specified 'netNum', 'deviceNum', 'moduleNum', 'chanNum', 'settingNum', 'fieldNum' parameters are correct. See *Chapter 8.*
45	iNetErr_-WriteOnly-Field	Cannot read from this field, write only	Make sure the specified 'netNum', 'deviceNum', 'moduleNum', 'chanNum', 'settingNum', 'fieldNum' parameters are correct. See *Chapter 8.*
46	iNetErr_-FieldValue-OutOfRange	Tried to set a field with a value that is too high or low	Make sure the specified 'netNum', 'deviceNum', 'moduleNum', 'chanNum', 'settingNum', 'fieldNum' parameters are correct. See *Chapter 8.*
47	iNetErr_-ArgTypeOut-OfRange	ArgType parameter is out of range	Make sure specified 'argType' parameter is correct. See list of valid 'instruNetDataType' values in interface .h file.
48	iNetErr_-BadKeyIn-Field-Hierarchy	A BAD key was found in the field hierarchy data -- internal data might be corrupted	Check network cables. Make sure a network terminator is properly installed. Latest version of instruNet Driver might help. Try pressing Reset button. Resetting computer might help.
49	iNetErr_-Max_LT_-MinInField-Hierarchy	A maximum value is less than a minimum value in the field hierarchy -- internal data might be corrupted	Latest version of instruNet Driver might help. Try pressing Reset button. Resetting computer might help.

Table AII - Error Codes

50	iNetErr_-Hierarchy-FieldData-In-Trouble	Hierarchical field data is in trouble -- internal data might be corrupted	Latest version of instruNet Driver might help. Try pressing Reset button. Resetting computer might help.
51	iNetErr_-Channel-NameInvalid	The channel name is in trouble -- internal data might be corrupted	Latest version of instruNet Driver might help. Try pressing Reset button. Resetting computer might help.
52	iNetErr_-tempUnits_-outOfRange	temperature scale {C,K,F} out of range	Check temperature measurement hardware and software.
53	iNetErr_-sensorType_-outOfRange	sensor type out of range	Check sensor hardware and software.
54	iNetErr_-CircBufErr	circular digitizing data buffer error	Try a slower sample rate, or ask instruNet to do less while digitizing.
55	iNetErr_-DataBuffer-Overflow	circular digitizing data buffer overwrote data before it was read	Try a slower sample rate, or ask instruNet to do less while digitizing.
56	iNetErr_-PulledToo-MuchOn-LastPull	circular digitizing data buffer error where pulled too much on last pull	Try a slower sample rate, or ask instruNet to do less while digitizing.
57	ERequired_-fbx_DCIIR	At least one cutoff frequency (passband or stopband) is needed for each transition band of bandpass and bandstop digital filters	Check digital filter Frequency Cutoff fields.
58	EFreqToo-Large_fx_-DCIIR	Cutoff frequency must be less than half the sampling rate	Check digital filter Frequency Cutoff fields and make sure they are lower than half the sample rate.
59	EFreqsNot-Ascending_-DCIIR	Cutoff frequency negative or frequencies not in ascending order	Check digital filter Frequency Cutoff fields.
60	ERequired_-fx_DCIIR	Missing one or more cutoff frequencies	Check digital filter Frequency Cutoff fields.
61	ERequired_-adelx_DCIIR	Missing passband ripple and or stopband attenuation	Check digital filter Ripple and Attenuation fields.
62	EInvalidArg_-DCIIR	Invalid argument	Check digital filter fields.
63	EOrderToo-High_DCIIR	Necessary or specified filter order is too high -- maximum order is %d	Reduce the digital filter Attenuation field value, or increase the Ripple field value.
64	EEven_-ndeg_DCIIR	Filter order must be even for bandpass and bandstop filters -- order being increased by 1	Reduce the digital filter Attenuation field value, or increase the Ripple field value.
65	EOrderToo-Low_DCIIR	Specified filter order is too low -- order being automatically increased	Increase the digital filter Attenuation field value, or decrease the Ripple field value.

Table AII - Error Codes

66	EActualOrder-_DCIIR	Required filter order = %d (%s biquadratic section%s)	Check digital filter fields.
67	iNetErr_-InterfaceCom-piledBadly	a variable type in interface file (e.g. INET_INT.C) is bad	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
68	iNetErr_-BadInterface-Key	the 'key' field passed to driver is bad	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
69	iNetErr_-BadAddrPa-ssedToDriver	bad address passed to driver	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
70	iNetErr_-BadStatic-VarInDriver	bad static variable in driver	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
71	iNetErr_-BadInteger-MathInDriver	bad integer math in driver	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
72	iNetErr_-BadChannel-Type	bad channel Type	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
73	iNetErr_-CppCompiler-DidBad	Cpp compiler failed	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
74	iNetErr_-MemMngr_-Failed	Memory Manager failed	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
75	iNetErr_-Toolbox_-Failed	Toolbox failed	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
76	iNetErr_-CrtRect_-Failed	CrtRect failed	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
77	iNetErr_-DlogCode_-Failed	Dialog Code failed	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
78	iNetErr_-DrvrNeeds-Fpu_Failed	Driver file needs FPU	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
79	iNetErr_-iirCode_-Failed	iir code failed	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
80	iNetErr_-sprintf_Failed	sprintf failed	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
81	iNetErr_-DigitizeInit	Digitize initialization failed	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
82	iNetErr_-SPEoff	instruNet network error	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.

Table AII - Error Codes

83	iNetErr_-Halton	instruNet network error	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
84	iNetErr_-QPTQP	instruNet network error	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
85	iNetErr_-qBusy	instruNet network is busy before digitize	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
86	iNetErr_-abort	we aborted early	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
87	iNetErr_-cBusy	controller is busy doing something	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
88	iNetErr_-cNotFin	controller did not finish the command	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
89	iNetErr_-CodeGen	code generation segment error	Latest version of instruNet Driver might help.
90	iNetErr_-CPTQPbad	instruNet network error	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
91	iNetErr_-Compiler	compiler error	Latest version of instruNet Driver might help.
92	iNetErr_-bOverflow	driver or user ram buffer overflow	Try reducing the sample rate, making displays much smaller, plotting less PointsPerPixel.
93	iNetErr_-nonCompOS	non-compatible operating system	Latest version of instruNet Driver might help.
94	iNetErr_bad-ChPtsPerScan	bad channel Points-Per-Scan value	Try a different Points-Per-Scan (i.e. press Timing button) or '% sample rate'.
95	iNetErr_-DestBuff - NotFound	destination buffer not found	Latest version of instruNet Driver might help. Try pressing Reset button or Resetting computer Check Interface to, and installation of, instruNet Driver.
10000 to 10255	Controller Status Register Error	this is an error code from the instruNet controller Status register	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.
-1 to -32000	OS Error	this is an error code from the Operating System	Press Reset Button. Try doing things differently and hope it goes away. Latest version of instruNet Driver might help.

Table AII - Error Codes

III Working With Spreadsheets

instruNet supports the acquisition of data into instruNet World with Export to a spreadsheet, post-acquisition; and also supports the digitizing of data directly into an Excel spreadsheet, in realtime, via the "Direct To Excel" VBasic Example program. This program is compatibe with Version 8.0 of Excel (in Office 97), and requires that Visual Basic ≥4.0 be installed (or that the VB400032.dll be installed).

MERGED.TXT

	A	B	C	D
1	instruNet waves in merged TEXT form #2			
2				
3	Notes:			
4	Date & Time:	2/18/97	22:03:00	
5	ChanName:	Ch1 Vin+	Ch4 Vin+	Ch7 Vin+
6	UserName:	Ch1 Vin+	Ch4 Vin+	Ch7 Vin+
7	vUnits:	Volts	Volts	Volts
8	hUnits:	Secs	Secs	Secs
9	PtsPerScan:	10	10	10
10	₹foreLastScan:	0	0	0
11	?tsInLastScan:	10	10	10
12	1stPtTime:	0.00E+00	0.00E+00	0.00E+00
13	SamplePeriod:	1.00E-03	1.00E-03	1.00E-03
14	netNum:	1	1	1
15	deviceNum:	1	1	1
16	moduleNum:	1	1	1
17	chanNum:	1	4	7
18	BytesPerRow:	-1	-1	-1
19	FirstDataByte:	-1	-1	-1
20	key:	21940	21940	21940
21	1904secs:	2.939E+09	2.939E+09	2.939E+09
22	DataType:	5	5	5
23	Internal1:	5.00E+00	5.00E+00	5.00E+00
24	External1:	5.00E+00	5.00E+00	5.00E+00
25	Internal2:	-5.00E+00	-5.00E+00	-5.00E+00
26	External2:	-5.00E+00	-5.00E+00	-5.00E+00
27	Secs	Ch1 Vin+	Ch4 Vin+	Ch7 Vin+
28	0.00E+00	2.35E-03	-1.23E-03	1.83E-03
29	1.00E-03	2.35E-03	-2.45E-03	1.83E-03
30	2.00E-03	2.35E-03	-1.23E-03	6.12E-04
31	3.00E-03	3.57E-03	-1.23E-03	1.83E-03
32	4.00E-03	2.35E-03	-1.05E-05	1.83E-03
33	5.00E-03	2.35E-03	1.21E-03	6.12E-04

Exporting a file to a spreadsheet, post-acquisition, is done by first acquiring data into instruNet World software, saving it to disk in the form of a text file, and then opening that text file with a spreadsheet, as illustrated to the left. To do this, one would:

1. Run instruNet World.
2. Select channels for digitizing in the Network Page.
3. Press the Record tab.
4. Press the Setup button to open the Setup dialog. Select Digitize Into: To Ram Buffer, select File Type: Text Merge, select the desired Sample Rate, select the desired Pts Per Scan, set the No of Scans to 1, set Scan Mode to Oscillo, and press OK to exit the dialog.
5. Press the Network tab, press the Save button to save these settings to disk, and then press the Record tab to return to the Record page.
6. Press the Start button to begin recording, and the Stop button to stop recording.
7. Press the Save button (in the Record page) to save the data to disk in a text file named "MERGED.TXT". This file places each channel in its own column, and looks something like the illustration to the left when opened with a spreadsheet program.

Columns are separated with TAB characters, and rows are separated with CARRIAGE RETURN characters.

IV Working With Application Software

DASY*Lab*

instruNet is compatible with DASYLab software Version ≥ 4.01.11 with the instruNet Driver, and is available from DASYTEC, Inc. DASYLab with instruNet runs on a Windows 95 or NT computer and is full 32bit compatible.

DASYLab is the easy-to-use data acquisition software application. Its outstanding analysis and display features make it the ideal tool for many types of measurement and control applications. Designed as an open system, DASYLab contains drivers for more than 250 different data acquisition devices as well as software interfaces and extension toolkits. With its unique structure, DASYLab is able to acquire data up to 1 Mhz into the PC's RAM, stream data to disk at up to 400 kHz and display data online at up to 150 kHz.

LabVIEW

instruNet Drivers for the Macintosh & Windows 95/NT Version of LabVIEW ≥ 4 are available. The part numbers for these low cost drivers are listed below. Please consult their documentation for information on how to link instruNet to LabVIEW. In summary, they provide LabVIEW icons for many of the instruNet functions described in Ch4 Programming, and provide examples of their use.

#iNet-380	instruNet Drivers for Mac & Win95 LabVIEW
#iNet-380-10x	Ten more iNet-380's after buying 1st one
#iNet-381	instruNet LabVIEW Driver 1year Update

HP VEE

InstruNet is compatible with HP Vee Version ≥4.0 on Windows 95 and NT 4.0. Please download the instruNet-to-HP Vee interface files from www.instrunet.com.

MicroLab

instruNet is compatible with Version ≥1.30 of MicroLab/µLab, which includes the instruNet interface.

Origin

instruNet is compatible with Version ≥4.0 of Origin. Please download the instruNet-Origin interface files from www.instrunet.com.

TestPoint

InstruNet is compatible with TestPoint Version ≥3.0 on Windows 95 and NT 4.0. Please download the instruNet TestPoint interface files from www.instrunet.com.

V Working With instruNet Files

instruNet File Types

instruNet supports the following different file types for waveform data: Text, Text Merge, Binary, and Binary Merge.

Text Data is stored in text form, where each wave appears as a column of numbers, with one file for each channel. One can easily open these files with a word processor or spreadsheet.

Text Merge Text Merge is similar to Text, yet includes an additional text file called "Merged.txt" which contains all channels in one file with one column devoted to each channel. This is useful for opening the entire dataset into one spreadsheet file.

Binary Data is stored in binary form, with one file for each channel. A binary header is stored at the beginning of the file, in the form of one GWI_file_header_struct struct (defined in file INET_INT.H), and this is followed by the wave data, stored in a one dimensional array of 32bit floating point numbers. The first 4 bytes in the header is the length of the header in bytes (i.e. 516 = 0x0204).

Binary Merge Binary Merge is similar to Binary, yet all channels are stored in one file, in an interlaced format. Binary Merge supports faster throughput rates than Binary, since the hard disk writing head stays in one place on the platter when writing multiple channels (as opposed to whipping back and forth between separate files for each channel). The beginning of the Binary Merge file contains an array of GWI_file_header_struct structs (defined in file INET_INT.H) for the various channels, followed by the interlaced 32bit floating point data. The first 4 bytes in the header is the length of the header for 1 channel in bytes (i.e. 516 = 0x0204). To read the # of channels stored in the file, read the 'channelsPerFile' field of the first struct (e.g. to see how many headers are there). After the header, the data is saved in an interlaced form, where points are stored in the order that they are acquired in time. For example, data from 3 channels (A, B and C) at the same sample rate would be stored as:

```
A[0], B[0], C[0], A[1], B[1], C[1], A[2], B[2], C[2] .....
```

If Channel B was stored at 1/N of the sample rate where N is 2 (N is ALWAYS and integer, and is defined in the 'sampleRate_Divider' field), the data would be packed in the following way:

```
A[0], B[0], C[0], A[1], C[1], A[2], B[1], C[2], A[3], C[3] ....
```

The binary data is stored in Intel little endian (Windows) or 68k big endian (Macintosh) format, as noted by the 'file_endian' field in the header. Use the 'int32key', 'int32key_StructTest', 'int16key' and 'flt32key' fields to make sure you are reading things correctly, as defined in file INET_INT.H. These keys are preset to specific values. If you save the file on a Windows 95/NT computer, and load it on a Windows 95/NT computer, things should be ok. Byteswapping is necessay when saving on a bigEndian computer (e.g. Macintosh) and then loading on a littleEndian computer (e.g. Windows 95).

Reading instruNet Files From C

The C programmer can read instruNet data files either direclty via the standard C file I/O functions, or via file functions built into the instruNet driver.

To read/write data to/from an instruNet RAM BUFFER (user or driver), one can send a command to the Command field within the File Setting Group of a channel. To learn more about this, please read the INET_INT.C documentation on 'fldNum_File_fileCmd' and 'ion_FileCmdPopup'; and also strudy ExerciseFileSaveLoadCode() in file INET_EX1.C. These routines fascillitate paging in data that was spooled to disk. For example, if you spool 1000 scans to disk with 10K Pts-Per-Scan (10M total pts) and need to load into ram one scan at a time, for post acquisition processing, then one could send fileCmd_FileToRamBuffer or fileCmd_FileToUserBuffer commands into the instruNet driver to fascillitate the paging-in process.